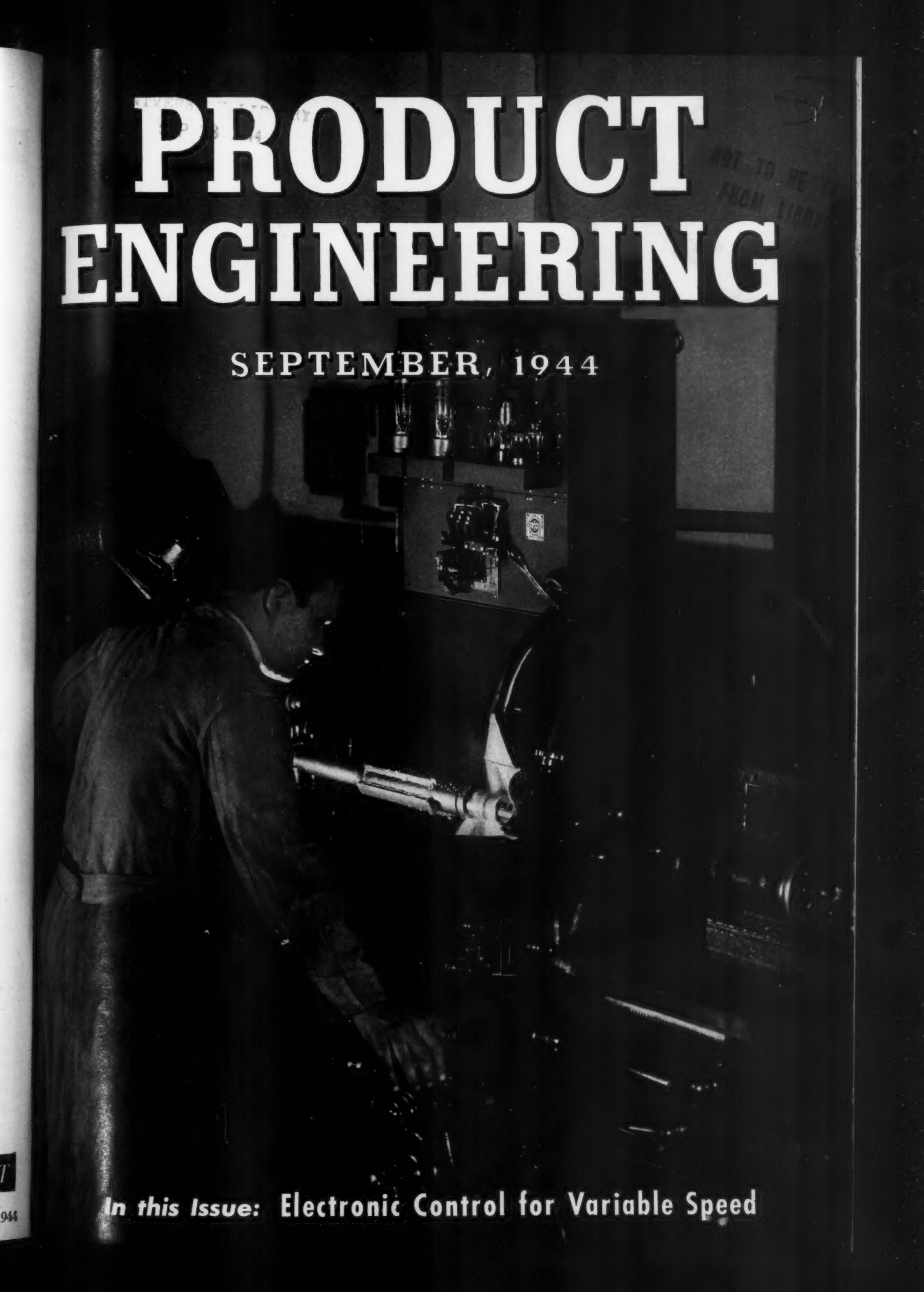
PRODUCT ENGINEERING

SEPTEMBER, 1944



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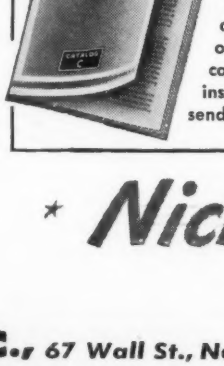

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PRODUCT ENGINEERING

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IN THIS ISSUE—

Cover Picture—An electronically controlled variable-speed lathe drive of Reliance Electric & Engineering Company.

Electronic Versus Electrical Drive

Electronic conversion and excitation are now available for variable-speed devices in which variable voltages are impressed upon d.c. motors. Previous units, developments of the Ward-Leonard system, utilized motor-generator-exciter sets. Each system has its advantages and disadvantages from the

product engineer's point of view. In an article beginning on page 586, J. W. Picking of Reliance Electric gives the pros and cons of each system.

Postwar Products

With the end of the war with Germany now in sight, the most persistent question asked by many manufacturers is, "How can we find postwar products to make?" In the article beginning on page 577 the reasoning and methods of procedure adopted by several companies are discussed.

Gear Lubrication

Too often a well-designed machine breaks down in service because the wrong lubricant was used for the gears. The American Gear Manufacturers Association has established definite specifications for open and enclosed gears, as presented on page 602 of this issue.

Hydraulic Packings

Refinements in hydraulic equipment to meet present-day aircraft requirements have brought improvement in packing rings. An article starting on page 581 gives design and performance details in seals used for reciprocating, rotary and static application. The results of tests made by Army and Navy aircraft experts are presented with illustrations showing effects of high pressures on the packing rings.

Thermal and Optical Properties of Plastics

Probably no other single factor is as important in the successful design of a plastic part as accurate and complete knowledge of the temperature properties of the material selected. Page 605 begins a discussion of thermal and optical properties of plastics from the standpoint of successful application. This is the fourth in a series of articles dealing with design of plastic parts by W. S. Larson of General Electric Plastics Department.

Spot Welds in Aluminum Alloys

The vastness of the field covered by the word "welding," and the constant and rapid change in aircraft welding techniques and processes, prompted the Sub-Committee on Methods Improvement of the Aircraft War Production Council, Inc., to investigate and study methods and applications of the several welding processes. Northrop's assignment included "Spot Welding Aluminum Alloys." James Ralston, spot welding engineering department, Northrop Aircraft, Inc., see page 608, discusses the results of the investigation.

Regenerative Braking Methods

Concluding article in the series discussing the basic characteristics of all-electric methods for braking. E. H. Hornbarger, control engineer, Westinghouse Electric & Manufacturing Company, see page 626, points out the important factors that should be considered when selecting and applying regenerative braking methods to stop a.c. induction motors, synchronous motors and d.c. motors.

Deflection of Coiled Springs

A proper understanding of initial tension and the amount that can be coiled into a spring has long been a perplexing problem in the design of extension springs. Harold Carlson, chief engineer, Lee Spring Company, see page 619, explains how initial tension is obtained and also analyzes the effect of initial tension on deflection.

Nameplate Design

Properly applied and designed, nameplates can be of considerable value to users of equipment. See page 615 for a resumé of methods of fabrication, materials and design considerations by B. A. Lee, nameplate designer, Westinghouse Electric & Manufacturing Company.

Surface Quality Standards

In the first of a series of articles on "Standards for Surface Quality," page 622, James A. Broadston, a recognized authority on this subject in the aircraft industries, discusses the significance of surface quality, surface roughness measurement and standards for surface quality.

Standards for Driven Rivets

To allow acceptance of a greater number of malformed rivets than is now permitted, a committee of the West Coast Aircraft War Production Council, see page 628, has prepared a summary report of tests of improperly driven rivets and acceptability limits for such rivets.

Correct Design for Ground Parts

An understanding of the problems in grinding cylindrical parts helps the engineer who designs such parts. S. H. Neady, assistant chief engineer, Landis Tool Company, see page 632, enumerates many design considerations that are dictated by production and machine limitations.

Temperature Effects On Phenolics

For charts giving effect of temperature on the mechanical properties of molded phenolic materials, see Reference Book Sheets, pages 647 and 648, by T. S. Carswell, D. Telfair, and R. U. Haslanger, plastics research division, Monsanto Chemical Company.

Lightening Tubular Structures

Improved methods of reducing the diameters of tube ends now make possible highly efficient lightweight tubular structures, according to A. Z. Bendar, Lockheed engineer who discusses the problem in an article starting on page 635.

WHAT'S COMING—

Special Section: Synthetic Rubbers

In the October number of PRODUCT ENGINEERING, a special editorial summary of new developments in synthetic rubbers will be presented, emphasizing types of compounds available, outstanding characteristics, typical applications. This report is the tenth insert in a continuing editorial service designed to acquaint engineers with the latest developments in materials, parts and processes.

Design Standards

Many companies faced with manpower shortages in engineering personnel have developed methods for standardizing design procedures. The Koehring Company utilizes a design manual which contains basic engineering information on materials, processes, and design formula. In the October number, a comprehensive article describes the method of development of such a manual.

PRODUCT ENGINEERING
SEPTEMBER, 1944

Study The Problem Before Seeking New Products

Each company's problem is different in details but in every instance there are fundamental steps to be taken in attacking the problem. Some of the steps are explained in this article. Methods used by a number of companies to find suitable products for postwar markets are described.

MANY manufacturers are apparently "all at sea" when it comes to searching for new products to manufacture in the postwar period. To all but a few, this poses an entirely new problem. Many refuse to face the fact that to do the job right will involve a great deal of "lost time" and what they unfortunately term "needless expense." Some manufacturers have the idea that the place to begin and end is to announce that they are searching for new products to manufacture and then sit down and await results. This procedure is not productive of results because practically all manufacturers are looking for new products.

Before a company starts looking for a postwar product to manufacture, it should make a careful study of the kinds of products it is best capable of making and selling. This will narrow the field of possible products to be considered. The manufacturer is then able to concentrate his efforts on a relatively narrow range of products in more or less definite fields. The philosophy of a West Coast manufacturer illustrates the effectiveness of such a procedure.

Before the war this company, which we will call the "Lamco Company," a fictitious name, employed about 75 people. It was a job shop specializing in plating and finishing. During the war it engaged in subcontracting work and the number of employees rose to 300. Company executives realized that they could not hope to maintain this employment if they did not find a postwar product to manufacture. So they hired a first-rate engineer from a neighboring aircraft plant to study the problem and make recommendations.

The philosophy of this engineer, whom we will call "Mr. Jones," is highly interesting. In view of the relatively high freight rates from the centers of steel production to the West Coast, he quickly decided that it would be most favorable to manufacture items requiring a relatively small amount of material and a large amount of labor. Secondly, because the company was too small to afford the services of numerous highly qualified engineers for research and experiment, it would be desirable or even essential that the items selected be of extremely simple design. This reduced the field of eligible postwar products to gadgets in the class of can openers and similar items.

Mr. Jones then studied marketing methods that might be employed. Obviously a small manufacturer employing between 200 and 250 men could not afford a national sales organization. So Mr. Jones quickly decided that his postwar products-to-be should be of a nature that could be marketed through mail order houses such as Sears Roebuck & Company and Montgomery Ward, or sold through the large chain stores such as Woolworth.

With his problem reduced to a narrow field, Mr. Jones procured a number of mail order catalogs and carefully studied the designs of the various gadgets pictured. Then he hired three engineers and under his direction they began making designs of various items, always seeking to improve the catalog designs. The aim was not only toward better designs functionally but also for improvements through the use of more suitable materials such as stainless steel in place of carbon steel, and plastic handles in place of wooden handles. The designs were then studied with reference to sales appeal features such as form and color and at the same time every detail of the production costs were analyzed. Thus the final production designs were developed.

Mr. Jones' procedure is significant in that he methodically analyzed the problem and thereby reduced his search for new products to a relatively narrow field. A tremendous amount of lost motion was avoided.

Another West Coast company used the same general philosophy in its search for postwar products. This company, which we will call the "Elton Manufacturing Company," also reasoned that it should confine its efforts to products that involved a large amount of productive labor and a small amount of material. In the prewar period the company employed about 200 people in the production of special instruments. During the war the company had grown to about 3,000 employees. It hopes to keep at least 2,000 busy during the postwar period. The company has an excellent, well-rounded engineering department. Because of the quality of the engineering staff it was logical that a great deal of thought should be given to products requiring an appreciable amount of engineering talent for their proper design.

A thorough study of the whole situation showed that this company would be in a favorable competitive position in the manufacture of electrical appliance such as toasters, percolators, waffle irons and similar devices. The figures showed that the total freight charges on such finished products shipped in from the East would be more than the freight charges on the raw mate-

First air-conditioned railway car, the diner Martha Washington, made its initial run on April 14, 1930, in a regular train from Baltimore to Cumberland, Md. The pioneering spirit of the late Daniel Willard, president of the B & O Railroad, led to successful introduction of air-conditioned railroad cars.

rial. Therefore this company decided to put its engineering efforts on the development of superior designs of electrical appliances. Executives are convinced that they are in an excellent position to sell their product through jobbers for retailing on the West Coast and as far east as the Mississippi River.

In both the above companies, the aim was to find their postwar products in the improved designs of existing items. For those companies that have the courage and financial ability, great opportunities are offered in the design of entirely new products, machines and devices that will render new services or fill unexpressed needs. The President of a highly successful 2,000-man company manufacturing small motors and radio accessories said:

"Every electric motor requires so much copper and so much iron and steel. The basic electrical requirements do not permit any appreciable economies in materials. The nature of the product is such that only small manufacturing economies are to be gained by the simplification of design details. Therefore it is obvious that the cost of the finished motors will be determined by the manufacturing efficiency of the company. It is safe to assume that there will be relatively little difference in the efficiency of the production operations of the various motor manufacturers in the postwar period. This means that there is going to be a terrific competitive situation. That is why we are looking for new products.

"During this war period our company has developed a high-grade engineering department, particularly electrical engineers. We have done a considerable amount of work in the field of radio. Hence we have qualified and experienced electrical engineers capable of developing designs of electronically operated products.

"With this in mind we have made an intensive study of the market possibilities of new devices hitherto unobtainable and also the improvement of existing products through the application of electronics. We now have designed six different products for which we have built models. As we get these models into proper shape we take them around and demonstrate them to selected individuals who should be interested in buying and using the product. We study the reactions of the people to whom we show the product and carefully analyze the value of the service that the product can render to the user. We are not certain which of these six products will prove to have the greatest possibilities in the postwar years but we are sure that at least two of them will have a good market and will enable us to continue in business with at least as many employees as we have now."

In each of the three companies mentioned above the management had a well defined plan of operation in the search for postwar products. Their experiences demonstrate the fact that the first step is a close study of the company organization with reference to the abilities of its engineering department, types of products the plant can manufacture economically, and the sales fields into which the company can go. This does not mean that a company should limit its field to a consideration of only those products that fit exactly into their existing engineering, production and sales organization.

Insofar as engineering and production are concerned, it is merely necessary that the considered products be in a class that can be handled by the existing organization or a reasonable expansion of it. This also applies to the marketing problem. The "Lamco Company" solved the sales problem by seeking outlets through available established sales organizations. The "Elton Manufacturing Company" made up its mind to organize the sales personnel required. This is also true of the motor manufacturer who is going to make electronic devices.

Too often a company refuses to contemplate possible products because it appears to them that their sales set-up cannot handle them. This is sometimes a mistake. For example, back in the 20's a large company in the field of railroad equipment was searching for new products to manufacture. When it was pointed out to them that the air-conditioning field, at that time in the beginning of a period of rapid growth, presented many possible opportunities, the company replied that their sales organization was not set-up to go into that field. The company was in an excellent financial condition and could have well afforded the cost of developing an entirely new sales organization from scratch. But the management felt that it might be able to find other products that could be handled by the existing sales organization more readily, and decided to look further.

It was ironical that within 10 years air-conditioning equipment became one of the essentials for railroad passenger cars. Had this company gone into the

field of commercial air-conditioning equipment it would have been in an excellent position to take the leadership in the design of air-conditioned passenger cars. This was not all. The frozen-food industry also created the requirement for precooled refrigerated cars and low-temperature refrigerated cars. Such products would have fitted in extremely well with a line of commercial refrigeration equipment specially designed for railroad use.

With reference to investigations of the possibilities in the manufacture of entirely new products that have not been manufactured previously, it is unfortunate that too much dependence is placed on so-called "market studies." The conventional market study is predicated on the sales records of similar articles or the voiced demand for products of the type under consideration. Unfortunately, many "market researchers" fail to recognize the fact that there cannot be a demand for a product that does not exist.

Fully aware of the fact that the conventional market research study would give an erroneous answer, the president of the company planning to manufacture new electronic-operated products adopted the more realistic procedure of first perfecting working models of the products he was thinking of manufacturing. He made his market research by letting prospective customers use, criticize and express their opinions of the new product models. Then he judged the possible market for the product, determining the quantities on the basis of the number of probable prospects.

Often great opportunities are found in improving the designs of products that have long been neglected. Wendell E. Whipp, executive of The Monarch Machine Tool Company, was asked his reasons for devoting his company's major effort to the development of engine lathes.

"The answer," he replied "is that the engine lathe field offered definite needs for development and improvement work. In our manufacturing program, we have always tried to learn from others, not only from those in our own industry but in other industries, and we have not hesitated to apply worthwhile improvements quickly."

Because of this policy, Monarch lathes often have led the field. The company was the first to have claimed hardened lathe parts and practically infallible electric controls, which by the mere pressing of a button regulate the cycle of lathe operation once the work is mounted. When, for example, the automotive industry adopted Duco paint, Monarch was quick to try the paint on its lathes. Within two months Duco paint was adopted for its lathes.

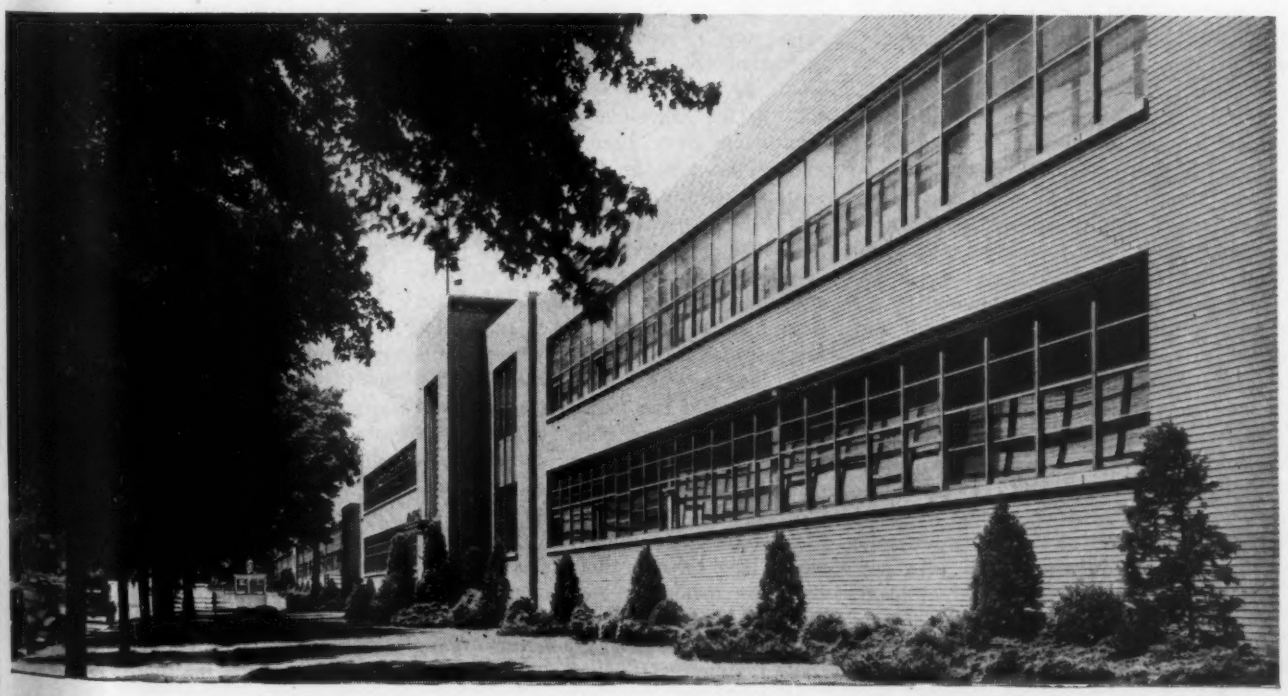
This willingness to investigate and adopt to its own use the advancements successfully developed in other fields is one of the many important steps which have contributed to making the company's product one of the most outstanding in its field.

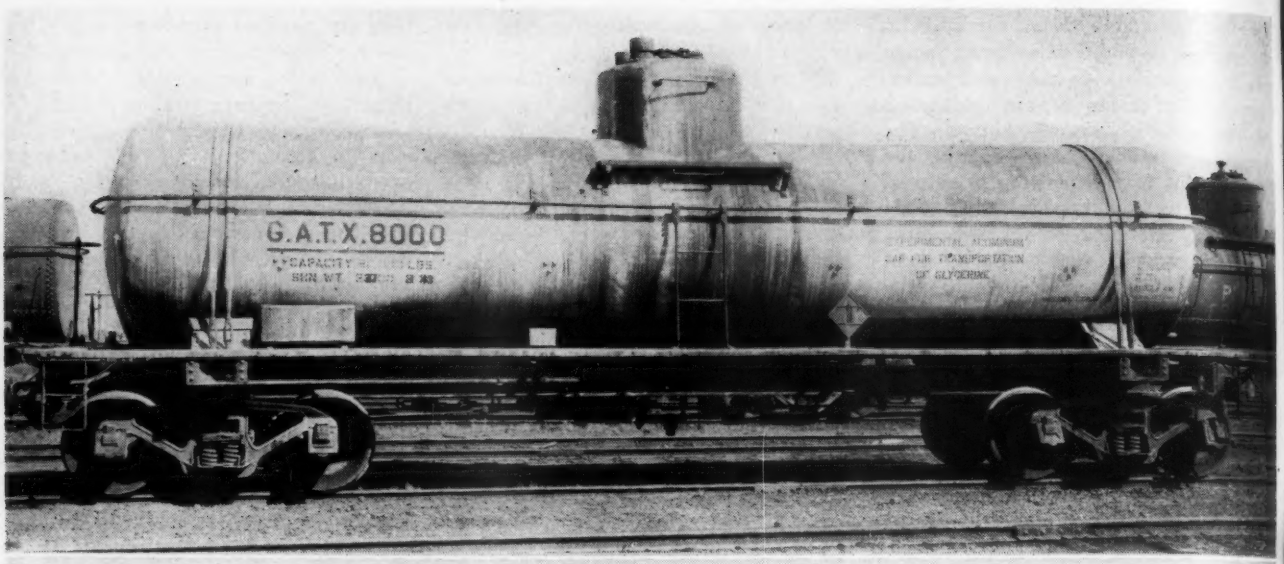
It is sad but true that innumerable new products must wait years before they are put into production solely because "there can be no demand for a product the like of which does not exist." Goodyear's rubber, Fulton's steamboat, Dr. Hall's aluminum, and even the automobile and airplane, were each given cold consideration by American business men and the buying public. This was because in each instance there was no public clamor for the product offered and business men could not appreciate that the public's cold reception of the new product was the natural accompaniment of lack of imagination and human inertia. As the saying goes, "It is wonderful how the human mind can resist a new idea."

One may argue that the above examples of over-conservatism in launching new products date back too far, and conditions today are entirely different. But it was only about 15 years ago that one of the largest railroads in this country refused to participate in the development of air-conditioned railroad passenger cars. It required the pioneering venturesome spirit of the late Daniel Willard, president of the Baltimore and Ohio Railroad, to introduce the air-conditioned passenger cars. The immediate public acceptance of this innovation is well known.

When the Aluminum Company of America tried to get the cooperation of a railroad equipment manufacturer to build a sample tank car with aluminum tank, the company in question made a market research. The study revealed that the only commodity that did not attack aluminum but had to be

Wendell Whipp's shrewdness in analyzing the machine tool field convinced him that engine lathes had shown little progress and thus offered a fertile field for his manufacturing plans. This view of the Monarch Machine Tool Company's large plant attests to the wisdom of making an exacting analysis of a product.





Aluminum tank cars are an important part of transportation equipment today, but it wasn't so long ago that a proposal for such cars was frowned upon as having little commercial possibility. Tank car shown was the first manufactured by General American Tank Corporation in 1928 for the Aluminum Company of America. Chemical companies became interested and before long hundreds of aluminum tank cars were being sold.

transported in bottles or carboys because it attacked steel, was acetic acid. The market researchers quickly discovered that only one tank car would be needed to transport all the acetic acid shipped, and hence recommended that the company refrain from embarking on the venture of making an aluminum tank car.

Aluminum Company of America then approached Bennett Epstein, president of the General American Transportation Corporation, also builders of tank cars. Mr. Epstein called in his chief engineer, asked if there were any insurmountable difficulties in the design and manufacture of such a car and upon getting "No" for an answer, proceeded in building a sample car.

Soon after the finished car with aluminum tank started on its exhibition tour it was discovered by interested chemical houses that here was the answer to the problem of transporting iron-free bleaching solutions. The aluminum tank was found suitable also for other commodities that did not attack steel but were contaminated by it. As a result, several hundred aluminum tank cars were soon built and sold.

In the search for postwar products, many companies simply go out and look for them, interviewing advertising agencies, patent lawyers, consulting engineers and market counsellors. Some companies offer prizes for suggestions submitted by employees. Others have advertised. All of these avenues are commendable but of little value if the company itself has no ideas as to what it is looking for.

One company advertised in a number of magazines for suggestions for postwar products. Several hundred suggestions poured in but only one was obviously sound while only four others warranted further investigation. Many of the ideas submitted were merely novel, some were technically unsound.

The new products division of the Committee for Economic Development has been approached a great number of times with the suggestion that an organization be established to serve as a clearing house between individuals who have postwar product ideas and manufacturers who are looking for postwar products. Obviously, as less than one out of a thousand ideas are even worth investigating further, the operating efficiency of such a bureau would be extremely low. It is claimed that a few excellent ideas for war equipment have been obtained from among the tens of thousands of suggestions submitted to the Office of Scientific Research and Development, the government bureau organized to receive suggestions for improved military equipment. However, cost is not and should not be reckoned when searching for weapons to defend the country and prosecute a war. War is admittedly wasteful. But the fact that so few excellent ideas were obtained from the tens of thousands offered clearly indicates the practical impossibility of operating a clearing house for ideas on postwar products. Such an organization would have to serve thousands of manufacturers instead of one client, as in the case of O.S.R.D., further complicating the problem. If a business organization were established for such an operation it would soon go bankrupt, indicating that the value of the service rendered is less than the cost of operating such a clearing house.

For the Smaller War Plants Corporation, or Small Business Corporation, as it is called, to conduct a clearing house to serve small manufacturers in their search for postwar products would be unsound for the same reasons. With rare exceptions, the obviously worthwhile products are quickly taken up by some manufacturer or other without the services of any clearing house. Only the most dubious ideas would be submitted to a clearing house.

There is no easy road in the search for new products. Nor is there any formula that will obtain the desired result. Success can only be attained by first analyzing the nature of products that might possibly be handled successfully and secondly, studying that field of products thoroughly and systematically. With the field thus narrowed the manufacturer is then prepared to start his active searching. The search may include alien patents, contacts with patent attorneys, a search of the patent files to establish the history and state of the art, consultation with marketing organizations in the fields selected, studies of possible consumer needs and desires, and a continuing program of developing tentative designs of possible products. There is no formula that solves the problem. The answer can be found only by prospecting after having made a sensible survey. It is much like prospecting for gold. But the problem should always be studied before beginning the search for the answer.

O-Ring Packings Simplify Lightweight Hydraulic Equipment

Design of O-ring packings and glands, their advantages and limitations, are presented from experience and standards developed for lightweight hydraulic equipment. Details of dimensional tolerances, materials, lubrication, finish of running surfaces, frictional characteristics, and causes of failure are given. Reciprocating, static, and rotary seal applications are considered.

THE use of higher operating pressures to decrease the size and weight of hydraulic equipment for aircraft has required further improvements in packings and their applications. Such packings must give nearly perfect non-leaking running seals at all temperatures ranging from −65 to 160 deg. F. and at operating pressures as high as 3,000 lb. per sq. in. Even higher pressures are contemplated.

A number of different materials are used for such packings. Army-Navy Specification AN-HH-P-114b requires an oil-resistant, synthetic rubber material having properties given by Tables I, II, and III. This material is suitable only for standard hydraulic mineral oil, Specification AN-VV-O-366, and not for aromatic gasolines, vegetable oils, and certain other fluids. Other synthetic materials, rubbers and impregnated leathers for these types of packing rings are in common use in applications where temperature range is not so great, leakage requirements less severe, and pressures are either

Table I—Physical Properties of O-rings at Manufacture

From AN-HH-P-114b

Item	Property	Class A Material	Class B Material
1	Hardness at 75 ± 5 deg. F. (Shore "A" Durometer) (min.)	88	68
2	Tensile strength, min., lb. per sq. in.	1,000	1,200
3	Elongation (ultimate), min. percent	50	175
4	Compression set high temperature (max.)	15 percent original compression that does not return.	15 percent original compression that does not return.
5	Compression set low temperature (max.)	90 percent at once and 60 percent after one hour, of original compression that does not return.	90 percent at once and 60 percent after one hour, of original compression that does not return.
6	Linear Contraction 70 to − 65 deg. F., percent max.	1.2	1.2
7	Cold bending at − 65 deg. F.	90 deg. min. bend without cracking or breaking. Shall be pliable.	180 deg. min. bend without cracking or breaking. Shall be pliable.
8	Tear resistance of O-rings in two planes (min.)		8 pounds pull. Tear of 3/8 in. before breakage not permitted in either plane.

Table II—Maximum Permissible Variation in Physical Properties of Production Batches From Contractor's Qualification Values

From AN-HH-P-114b

Item	Property	Class A or Class B
1	Specific gravity, percent	±2.0
2	Hardness, Shore "A" Durometer at 75 ± 59 deg. F.—points	±3*
3	Tensile strength, percent	±15
4	Elongation, percent	±20
5	Compression set, high temperature	Not greater than value determined in qualification tests.
6	Compressure set, low temperature	
7	Linear contraction	
8	Cold bending of original, air and oil aged samples	Not less than value determined in qualification tests.
9	Tear resistance	
10	Corrosion, oil and air	None and no adhesion.
11	Volume change	Swell determined from qualification test value ±1.†

* Shore hardness on production packings shall not be less than 65 for Class B nor 85 for Class A with this tolerance applied.

† Example: If qualification swell is + 1 percent, then limits can be 0 to 2 percent, or if + 5 percent, then limits can be 4 to 6 percent.

Table III—Permissible Change in Physical Properties by Air and Oil Aging

From AN-HH-P-114b

Item	Property	Class A	Class B
1	Tensile strength, decrease, percent max.	30	20
2	Elongation, decrease, percent max.	40	30
3	Hardness change, Points Shore Durometer	±9	±7
4	Volumetric change, upon aging in hydraulic oil, percent	0 to +6	0 to +6
5	Corrosion and adhesion	None	None
6	Cold bending at −65 deg. F.	No Change	No Change

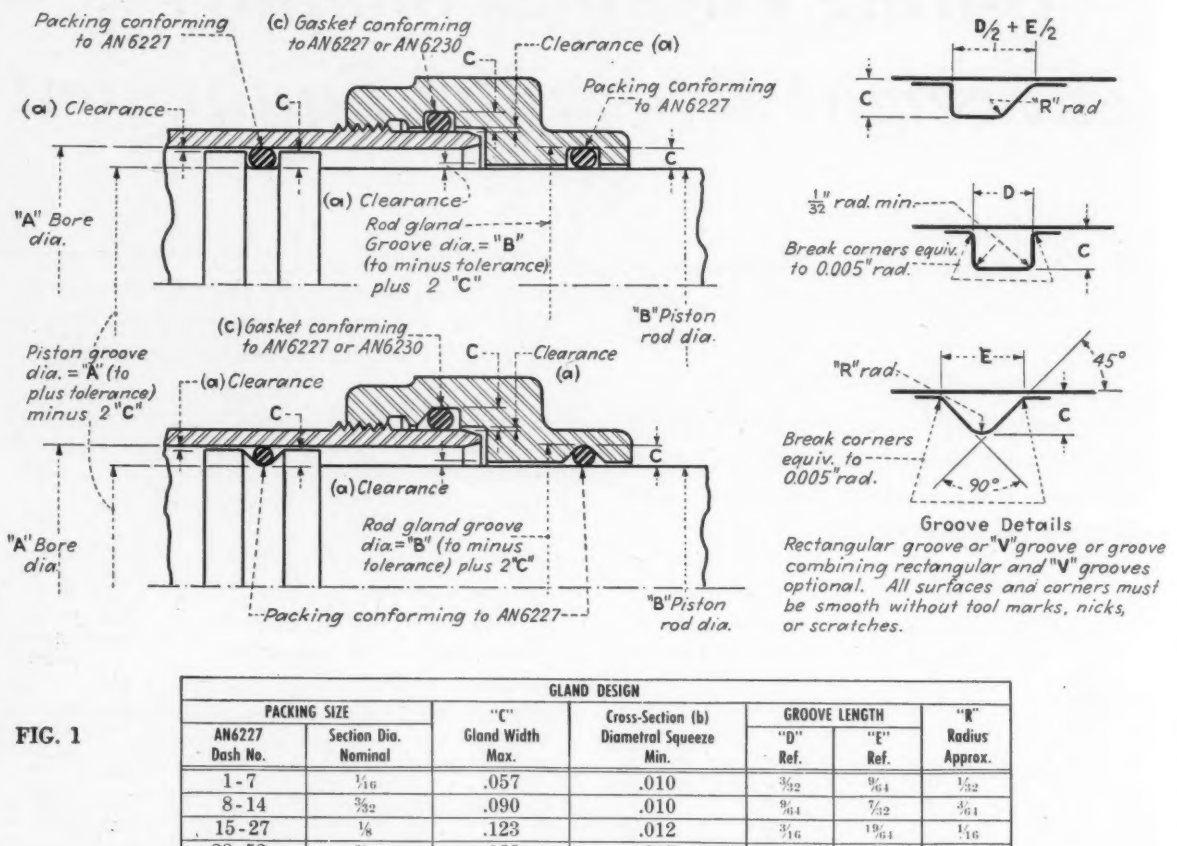

Packing conforming to AN6227
(c) Gasket conforming to AN6227 or AN6230
Clearance (a)
(a) Clearance
C
Packing conforming to AN6227
"A" Bore dia.
Rod gland Groove dia. = "B" (to minus tolerance) plus 2 "C"
"B" Piston rod dia.
Piston groove dia. = "A" (to plus tolerance) minus 2 "C"
Rod gland groove dia. = "B" (to minus tolerance) plus 2"C"
Packing conforming to AN6227
D/2 + E/2
"R" rad
1/32" rad. min.
D
Break corners equiv. to 0.005" rad.
"R" rad.
E
45°
90°
Groove Details
Rectangular groove or "V" groove or groove combining rectangular and "V" grooves optional. All surfaces and corners must be smooth without tool marks, nicks, or scratches.

FIG. 1

GLAND DESIGN						
PACKING SIZE		"C"	Cross-Section (b)	GROOVE LENGTH		"R"
AN6227 Dash No.	Section Dia. Nominal	Gland Width Max.	Diametral Squeeze Min.	"D" Ref.	"E" Ref.	Radius Approx.
1-7	1/16	.057	.010	3/32	9/64	1/32
8-14	3/32	.090	.010	9/64	7/32	3/64
15-27	1/8	.123	.012	3/16	19/64	1/16
28-52	3/16	.188	.017	9/32	15/32	3/32
53-88	1/4	.240	.029	3/8	39/64	1/8

(a) "Clearance" must be held to an absolute minimum consistent with design requirements for temperature range variation.
(b) "Cross-section diametral squeeze" indicates minimum allowable interference dimension between packing cross-section diameter and dimension "C".
(c) When AN6230 Gasket O-Ring is used, design gland same as AN6227-15 to -27 packings. See example three below.

DESIRED ACTUAL GLAND DIAMETERS

PACKING SIZE NOMINAL								PACKING SIZE NOMINAL								PACKING SIZE NOMINAL							
AN6227 O-Ring Dash No.	Sect. Dia.	ID	OD	"A" Bore Dia. ±.001	Piston Groove Dia. +.002 −.000	"B" Rod Dia. ±.001	Rod Gland Groove Dia. +.000 −.002	AN6227 O-Ring Dash No.	Sect. Dia.	ID	OD	"A" Bore Dia. ±.001	Piston Groove Dia. +.002 −.000	"B" Rod Dia. ±.001	Rod Gland Groove Dia. +.000 −.002	AN6227 O-Ring Dash No.	Sect. Dia.	ID	OD	"A" Bore Dia. ±.001	Piston Groove Dia. +.002 −.000	"B" Rod Dia. ±.001	Rod Gland Groove Dia. +.000 −.002
1	1/16	1/8	1/4	.250	.137	.123	.236	31	3/16	1 7/8	2 1/4	2.251	1.877	1.872	2.246	61	1/8	5 3/4	6 1/4	6.128	5.649	5.621	6.100
2	1/16	5/32	9/32	.281	.168	.154	.267	32	3/16	2	2 3/8	2.376	2.002	1.997	2.371	62	1/8	5 7/8	6 1/8	6.253	5.774	5.746	6.225
3	1/16	3/16	5/16	.312	.199	.185	.298	33	3/16	2 1/8	2 1/2	2.501	2.127	2.122	2.496	63	1/8	5 7/8	6 3/8	6.378	5.899	5.871	6.350
4	1/16	7/32	11/32	.344	.231	.217	.330	34	3/16	2 1/4	2 5/8	2.626	2.252	2.247	2.621	64	1/8	6	6 1/2	6.503	6.024	5.996	6.475
5	1/16	1/4	3/8	.375	.262	.248	.361	35	3/16	2 3/8	2 3/4	2.751	2.377	2.372	2.746	65	1/8	6 1/8	6 3/8	6.753	6.274	6.246	6.725
6	1/16	5/16	7/16	.4375	.3245	.310	.423	36	3/16	2 1/2	2 7/8	2.876	2.502	2.497	2.871	66	1/8	6 1/2	7	7.003	6.524	6.496	6.975
7	1/16	3/8	1/2	.500	.387	.373	.486	37	3/16	2 5/8	3	3.001	2.627	2.622	2.996	67	1/8	6 3/4	7 1/4	7.253	6.774	6.746	7.225
8	3/32	3/8	9/16	.5625	.3835	.373	.552	38	3/16	2 3/4	3 1/8	3.126	2.752	2.747	3.121	68	1/8	7	7 1/2	7.503	7.024	6.996	7.475
9	3/32	7/16	5/8	.625	.446	.435	.614	39	3/16	2 7/8	3 1/4	3.251	2.877	2.872	3.246	69	1/8	7 1/8	7 3/8	7.753	7.274	7.246	7.725
10	3/32	1/2	11/16	.6875	.5085	.498	.677	40	3/16	3	3 3/8	3.377	3.003	2.996	3.370	70	1/8	7 1/2	8	8.003	7.524	7.496	7.975
11	3/32	9/16	3/4	.750	.571	.560	.739	41	3/16	3 1/8	3 1/2	3.502	3.128	3.121	3.495	71	1/8	7 7/8	8 1/4	8.253	7.774	7.746	8.225
12	3/32	5/8	13/16	.8125	.6335	.623	.802	42	3/16	3 1/4	3 5/8	3.627	3.253	3.246	3.620	72	1/8	8	8 1/2	8.503	8.024	7.996	8.475
13	3/32	11/16	7/8	.875	.696	.685	.864	43	3/16	3 3/8	3 3/4	3.752	3.378	3.371	3.745	73	1/8	8 1/8	9	9.003	8.524	8.496	8.975
14	3/32	3/4	15/16	.9375	.7585	.748	.927	44	3/16	3 1/2	3 7/8	3.877	3.503	3.496	3.870	74	1/8	9	9 1/2	9.503	9.024	8.996	9.475
15	1/8	3/4	1	1.001	.756	.747	.992	45	3/16	3 5/8	4	4.002	3.628	3.621	3.995	75	1/8	9 1/2	10	10.003	9.524	9.496	9.975
16	1/8	1 3/16	1 1/16	1.063	.818	.809	1.054	46	3/16	3 7/8	4 1/4	4.127	3.753	3.746	4.120	76	1/8	10	10 1/2	10.503	10.024	9.996	10.475
17	1/8	1/4	1 1/4	1.126	.881	.872	1.117	47	3/16	3 7/8	4 1/2	4.252	3.878	3.871	4.245	77	1/8	10 1/2	11	11.003	10.524	10.496	10.975
18	1/8	1 5/16	1 3/16	1.188	.943	.943	1.179	48	3/16	4	4 3/8	4.377	4.003	3.996	4.370	78	1/8	11	11 1/2	11.503	11.024	10.996	11.475
19	1/8	1	1 1/4	1.251	1.006	.997	1.242	49	3/16	4 1/8	4 1/2	4.502	4.128	4.121	4.495	79	1/8	11 1/2	12	12.003	11.524	11.496	11.975
20	1/8	1 1/16	1 5/16	1.313	1.068	1.059	1.304	50	3/16	4 1/4	4 5/8	4.627	4.253	4.246	4.620	80	1/8	12	12 1/2	12.503	12.024	11.996	12.475
21	1/8	1 1/8	1 3/8	1.376	1.131	1.122	1.367	51	3/16	4 3/8	4 3/4	4.752	4.378	4.371	4.745	81	1/8	12 1/2	13	13.003	12.524	12.496	12.975
22	1/8	1 3/16	1 7/16	1.438	1.193	1.184	1.429	52	3/16	4 1/2	4 7/8	4.877	4.503	4.496	4.870	82	1/8	13	13 1/2	13.503	13.024	12.996	13.475
23	1/8	1 1/4	1 1/2	1.501	1.256	1.247	1.492	53	1/8	4 3/8	5 1/8	5.128	4.649	4.621	5.100	83	1/8	13 1/2	14	14.003	13.524	13.496	13.975
24	1/8	1 5/16	1 9/16	1.563	1.318	1.309	1.554	54	1/8	4 3/4	5 1/4	5.253	4.774	4.746	5.225	84	1/8	14	14 1/2	14.503	14.024	13.996	14.475
25	1/8	1 3/8	1 5/8	1.626	1.381	1.372	1.617	55	1/8	4 7/8	5 3/8	5.378	4.899	4.871	5.350	85	1/8	14 1/2	15	15.003	14.524	14.496	14.975
26	1/4	1 7/16	1 11/16	1.688	1.443	1.434	1.679	56	1/8	5	5 1/2	5.503	5.024	4.996	5.475	86	1/8	15	15 1/2	15.503	15.024	14.996	15.475
27	1/4	1 1/2	1 3/4	1.751	1.506	1.497	1.742	57	1/8	5 1/8	5 5/8	5.628	5.149	5.121	5.600	87	1/8	15 1/2	16	16.003	15.524	15.496	15.976
28	3/16	1 1/2	1 7/8	1.876	1.502	1.497	1.871	58	1/8	5 1/4	5 3/4	5.753	5.274	5.246	5.725	88	1/8	4 1/2	5	5.003	4.524	4.496	4.975
29	3/16	1 5/8	2	2.001	1.627	1.622	1.996	59	1/8	5 3/8	5 7/8	5.878	5.399	5.371	5.850								
30	3/16	1 3/4	2 1/4	2.126	1.752	1.747	2.121	60	1/8	5 1/2	6	6.003	5.524	5.496	5.975								

Examples: (See formulae above).
First: Piston Head Groove for 5⅛ in. Nominal Bore Dia.: Pick AN6227-53 O-Ring Packing (5⅛ in. OD). Groove Dia. = (5.128 +.001) − 2 × .240 = 4.649 +.002 −.000, or 4.650 ±.001.
Second: Rod Groove for 1 in. Nominal OD Piston Rod: Pick AN6227-19 O-Ring Packing (1 in. ID). Groove Dia. = (.997 −.001) + 2 × .123 = 1.242 +.000 −.002, or 1.241 ±.001.
Third: End Cap Static Seal Groove Dia. for Cylinder End of 5.375 ±.001 Actual OD: Pick AN6230-31 O-Ring Gasket (5⅜ in. ID). Groove Dia. = (5.375 −.001) + 2 × .123 = 5.620 +.000 −.002 (External End Cap Groove and Piston Rod Groove Diameters are determined by same formula).
Dimensions in inches.

ARMY-NAVY AERONAUTICAL DESIGN STANDARD

GLAND DIMENSIONS – "O" RING HYDRAULIC PACKING AND GASKET

AND10073

several times greater or much lower. Packing materials are also varied to suit different hydraulic fluids under different conditions of service.

Various shapes of ring-type packings are in general use. The doughnut or O-ring packing is becoming increasingly popular because of its simplicity. Only one ring is required for sealing, recesses for the rings are merely grooves machined in either a piston or cylinder wall, and no backing rings are required for 1,500-lb. service. They hold pressure in both directions in a cylinder and cannot be installed backward. A possible objection as compared with V-rings is the factor of safety. It is not possible to use two or more rings together because pressure would build up between the rings. However, experience with O-rings has been sufficiently satisfactory to justify increasing use in aircraft.

Two general shapes of grooves for O-rings are shown in Fig. 1. Either one or a combination of the two are approved. The minimum squeeze, or *C* dimension, is the same in both, as indicated by detailed sketches in Fig. 1. In general, O-rings have equal life in Vee grooves or rectangular grooves for running-type seals if pressures are equal.

Vee grooves produce a slight increase in friction but they simplify removal and installation of O-rings. Their chief advantage is in static seals, however, where pressures up to 3,000 lb. per sq. in. can be held if surface and edges are smooth and clearances are held to a minimum so that no extrusion can occur. Rings of small cross-section, standard drawing AN 6230, can be used for this purpose. If a rectangular groove must be used, the O-rings of standard drawing AN 6227 should be used. Fig. 2 shows the effect of increasing pressure on O-rings in rectangular and Vee grooves up to the extrusion point.

Disadvantage of the Vee groove is primarily in assembly. Vee grooves cause O-rings to wedge during assembly and may damage them seriously. The combination Vee and rectangular groove can be used to advantage if the direction of assembly and pressure application are the same, since O-rings in rectangular grooves can be installed easily and safely.

Fig. 1 shows how to design an O-ring packing gland for running and static O-ring seals. Groove diameters and tolerances for both piston grooves and rod gland grooves of SAE standard cylinder bores and piston rod diameters are listed. The O-ring sizes, totaling 88, range from ¼ to 16 in. in nominal outside diameters. Actual sizes of rings used in aircraft equipment are held to close tolerances given by standard drawing No. AN 6227. When diameters of bore or rod are between listed values, groove diameters are determined by the Fig. 1 formulas. For example:

1. Piston head groove for 5⅛-in. nominal bore diameter. Use O-ring No. 53 having O.D. of 5⅛ in. Groove dia. $= (5.128 + 0.001) - 2 \times 0.240 = 4.649 \frac{+0.002}{-0.000}$ or 4.650 ± 0.001 in.

2. Rod groove for 1-in. nominal O.D. piston rod. Use O-ring No. 19 having I.D. of 1 in. Groove dia. $= (0.997 - 0.001) + 2 \times 0.123 = 1.242 \frac{+0.000}{-0.002}$ or 1.241 ± 0.001 in.

When standard bores or rods are used, the applicable packing has no resultant stretch or compression at the neutral diameter of the ring after installation. In a simulated non-standard piston head installation, the next smaller size ring should be selected and in a simulated non-standard piston rod installation the next larger size ring should be selected. This rule is based primarily on ease of assembly.

The chief cause of failure or disintegration of O-rings, assuming a good compound and proper molding, is extrusion through the clearance gap between the piston adjacent to the groove and cylinder barrel wall, or the equivalent clearance in rod glands, as shown in Fig. 2. It is for this reason that clearance must be held to an absolute minimum consistent with thermal expansion or contraction coefficients of the materials of the mating parts.

Numerous types of packings have been proposed for aircraft hydraulic use at pressures greater than 1,500 lb. per sq. in., particularly for 3,000-lb. systems, which are covered by general hydraulic system Specification AN-H-2A. The O-ring can be used as a running seal at this pressure if non-extrusion devices are added in the groove between the O-ring and the sides of the groove. Such a device, in general, is a thin split ring that can expand or compress diametrically so that the O.D. or I.D. always contacts cylinder wall or piston rod. The non-extruding backing ring must be of such shape that it does not cut the O-ring. The split is usually made at an angle so that the ends overlap considerably and the opening does not pinch the ring.

The Jackman packing functions in many respects like an O-ring packing with non-extruding backing rings. It has been successful in tests at 3,000 lb. per sq. in. and experimental work has been done at 10,000 lb. This packing has a Tee section, the rounded foot of the Tee being the sealing face. Split rings of harder material on each side of the leg of the Tee serve to prevent extrusion of the packing material into the clearance space. Edges of these rings are forced across the clearance space by thickening of the arms of the Tee, which results from compression

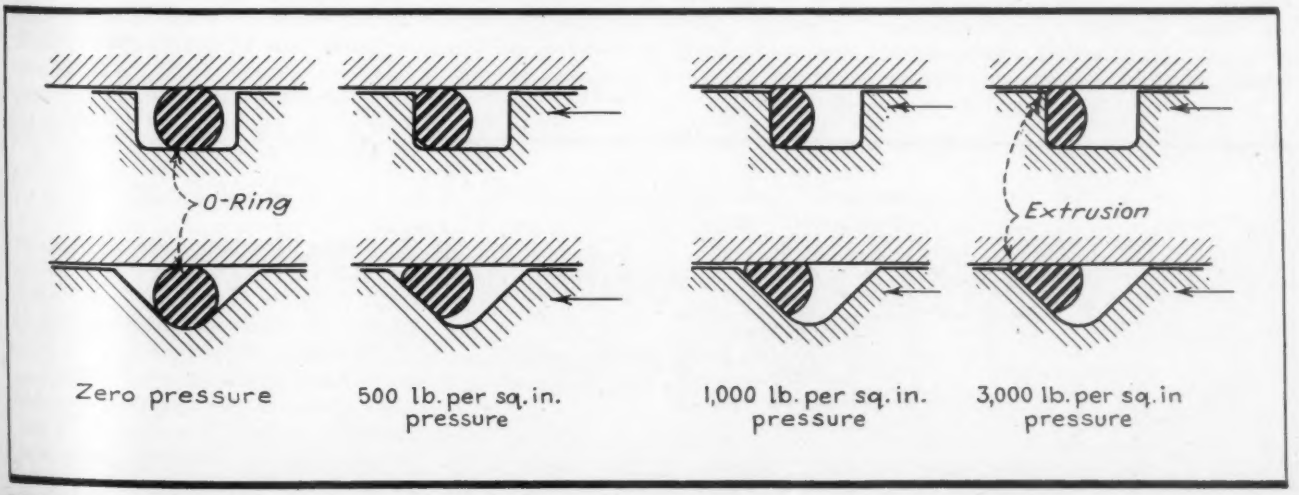


Fig. 2—O-rings extrude into the clearance space between the heel of the groove and the running surface when the pressure becomes too great. Ring distortion is shown at three pressures in rectangular and Vee grooves of standard design.

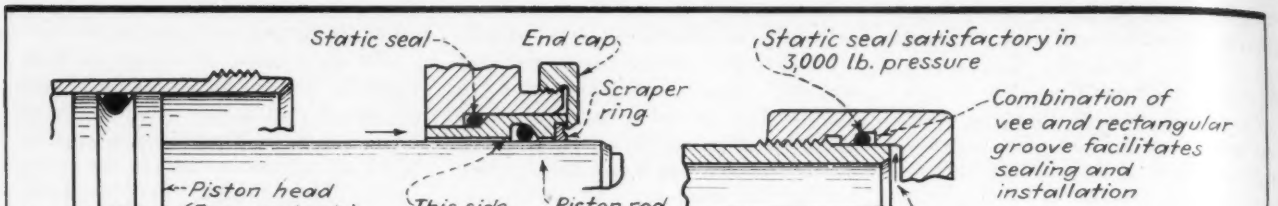

Static seal
End cap
Scraper ring
Piston head (Two-way loads)
This side either vee or rectangle
Piston rod
(A) Typical O-Ring Applications
Static seal satisfactory in 3,000 lb. pressure
Combination of vee and rectangular groove facilitates sealing and installation
Pressure one way
(B) End Cap Static Seal
V-Groove
Pinched O-ring
(C) Possible Fault in Blind Assembly with Symmetrical V-Groove
Pressure
40°
Long 10 to 15 deg. taper
When V-groove is necessary, as in this installation, vary the angles to minimize tendency for O-ring to be forced into the thread undercut at assembly
(D) Internal End Static Seal

Fig. 3—V-grooves sometimes have a disadvantage in assembly, hence the combinaton Vee and rectangular groove are used.

of the leg under hydraulic pressure. The sealing member is a synthetic rubber suited to service conditions.

Groove Finish

Smooth finish is essential for O-ring grooves; either a smooth machine finish or a smooth ground finish. The groove surface can also be plated or anodically treated to attain a smooth finish. Nicks, scratches, or tool marks cause early failure of O-rings. Edges of the groove should be as sharp as possible without leaving a burr or razor edge. A 0.005-in. radius is recommended. The edge of the groove also must be free of nicks and dents. Instructions for removal and replacement of rings should emphasize this point.

The V-groove is usually easier to machine or grind because of the clearance for the heel of the cutter or grinding wheel. Machining the rectangular groove can be simplified without detrimental effect by allowing an approximate 7-deg. slope in the groove sides.

In actuating cylinders and similar unit designs for aircraft, selection of materials is important, especially as to bearing surfaces. Army-Navy specification for hydraulic actuating cylinders, AN-C-66b, requires steel cylinders. Aluminum cylinders, particularly when used with O-rings, scratch excessively during cycling. When using a steel cylinder barrel, usually chrome-moly 4130 heat-treated to 135,000 lb. per sq. in. maximum tensile strength, with various piston materials, the results given in Table IV were obtained.

Table IV—Effects of Piston Material on O-rings

Piston head material	Results	Comments
Aluminum alloy	Very bad	Scratches cylinder badly
Brass	Bad	Scratches cylinder badly
Bronze (bearing type)	Poor	Scratches cylinder badly
Steel (not heat-treated)	Fair	Little experience available
Steel, hardened	Excellent	Based on hardened and ground surface
Steel, chrome plated	Excellent	
*Phenolic, impregnated	Excellent	Oil and water resistant types

* Use of this material is limited by nherent weakness in physical properties. Usually no saving in weight can be realized in large diameter piston heads because increase in length of head is necessary to meet test requirements.

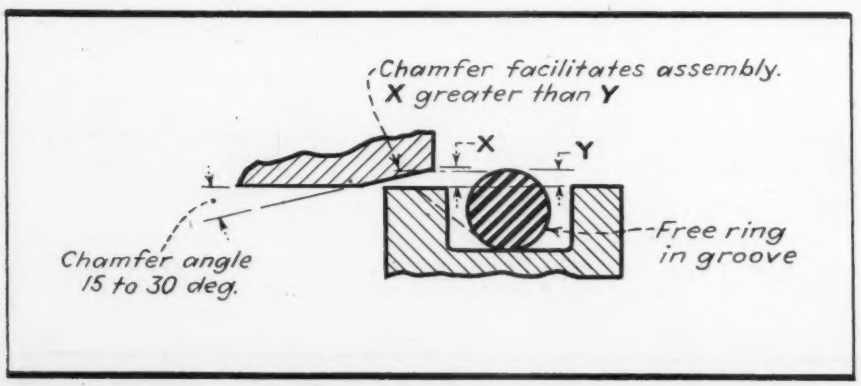


Fig. 4—Installation of O-rings is facilitated by a chamfer clearing the ring.

Rotary Seals

O-rings have been used successfully as seals for parts having rotary motion such as swivel or flex joints or rotary shaft seals. Their success depends upon (1) eliminating all possible side play by using minimum diametral clearance, (2) producing the smoothest possible finish on surface in contact with the O-ring, and (3) lubricating the seal adequately. These requirements have been attained usually by using hardened steel in both mating parts. Elimin-

ation of differential thermal coefficients of expansion acting on small clearances materially lessens binding. If O-rings are squeezed more on one side than on the other, or have more friction on one side than the other, bunching is produced at one section and stretching in an adjoining section. Leakage then occurs at the stretched section.

The maximum permissible speed of rotation is not known. Applications have involved relatively slow motion. At high speeds of rotation, local heat can be produced by friction, which if maintained in excess of approximately 150 deg. F. will accelerate aging and disintegration of present AN standard material.

Lubrication is essential in both rotary and reciprocating type service because dry O-rings have high friction. This is most objectionable in hydraulic equipment that is not operated continuously and contact surfaces have time to dry. Felt wiper rings placed in separate grooves on each side of O-rings in pneumatic cylinders help to retain grease in the O-ring groove. However, more development work is needed on this type of seal for pneumatic cylinders.

Where relatively high friction and breakout pressure may jeopardize the function of a unit when O-rings are used as running-type seals, thorough simulated life tests are essential. Running friction of O-rings is 1 to 5 percent higher than that of equivalent V-ring installations, depending on lubrication, squeeze, compound, and surface finishes. However, excessive squeezes do not affect running friction as much as might be expected. Lessening the squeeze, or *C* dimension in Fig. 1, usually increases leakage, particularly at low pressures.

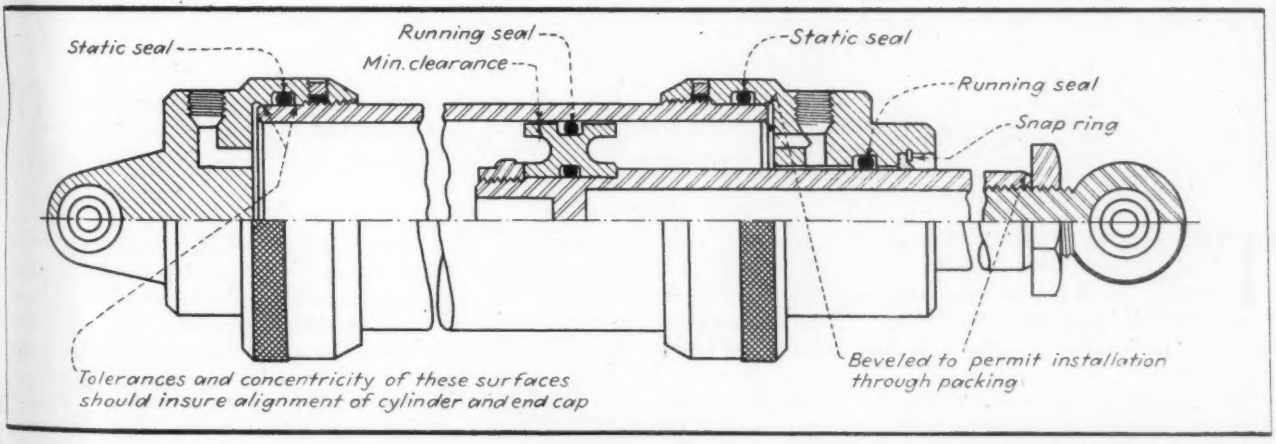
Breakout pressure, or pressure necessary to start motion, is 10 to 20 percent higher in O-ring installations than in equivalent V-ring installations. Breakout friction is dependent on surface finishes, lubrication, types of metal in contact with the O-ring, pressure under which the O-ring is allowed to set statically, and length of static period.

Finish of running surfaces has not been thoroughly studied, but it is now assumed that finishes equal to 5 to 10 microinch, root mean square, as measured with a Profilometer or Brush Analyzer give least friction. Too smooth a surface does not hold the essential minute lubricant particles, while too rought a surface imbeds the surface of the O-ring, thus increasing friction, particularly at breakout.

Present synthetic rubbers that are highly plasticized to be pliable at −65 deg. F. tend to discolor metals and to increase adhesion. This increases friction. This effect has been reduced where possible by plating or anodizing surfaces in contact with O-rings.

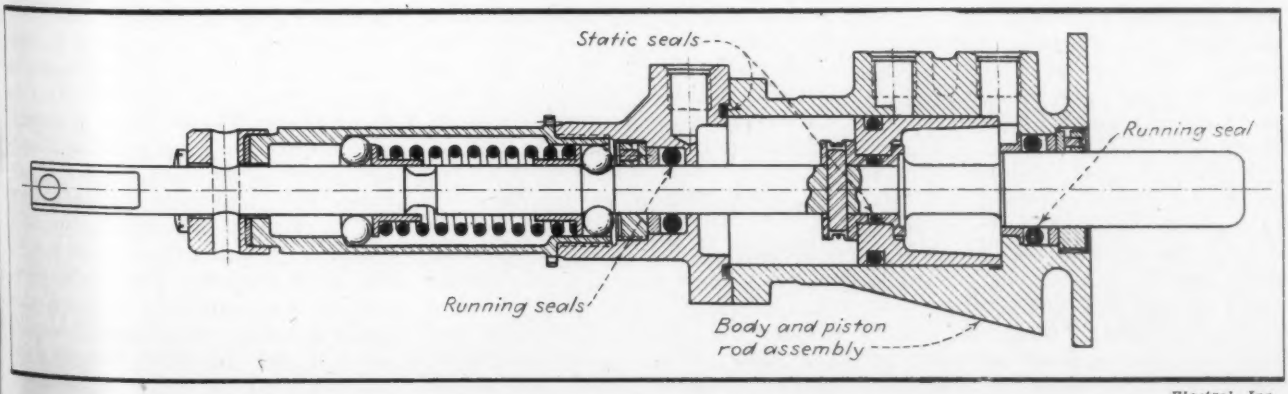
O-ring packings have not stood up satisfactorily under severe vibration, as in a flexible joint in the pressure or suction line of an engine-driven pump or a sequence valve in which the plunger is allowed to vibrate rapidly by being in contact with a vibrating pressure pad. Disintegration is probably aggravated by high amplitude surges induced by alternate pressurization and rarification of the fluid in the unit as the plunger vibrates in and out. No such failure has been noted in actuating cylinders on any unit having a relatively large volume of fluid or connected to a surge chamber, or that have other means of damping pressure fluctuations.

ACKNOWLEDGEMENT. Material in this article is based largely on information supplied by the Mechanical Branch of the Aircraft Laboratory, Materiel Command, Wright Feld, Dayton, Ohio. Specifications mentioned are available at the Specifications Section, Wright Field or Army Air Forces Headquarters, Washington, D. C.


Static seal
Running seal
Min. clearance
Static seal
Running seal
Snap ring
Tolerances and concentricity of these surfaces should insure alignment of cylinder and end cap
Beveled to permit installation through packing

Linear Packing & Rubber Company

Fig. 5—Typical aircraft hydraulic actuating cylinder with O-ring packings for both running and static seals.



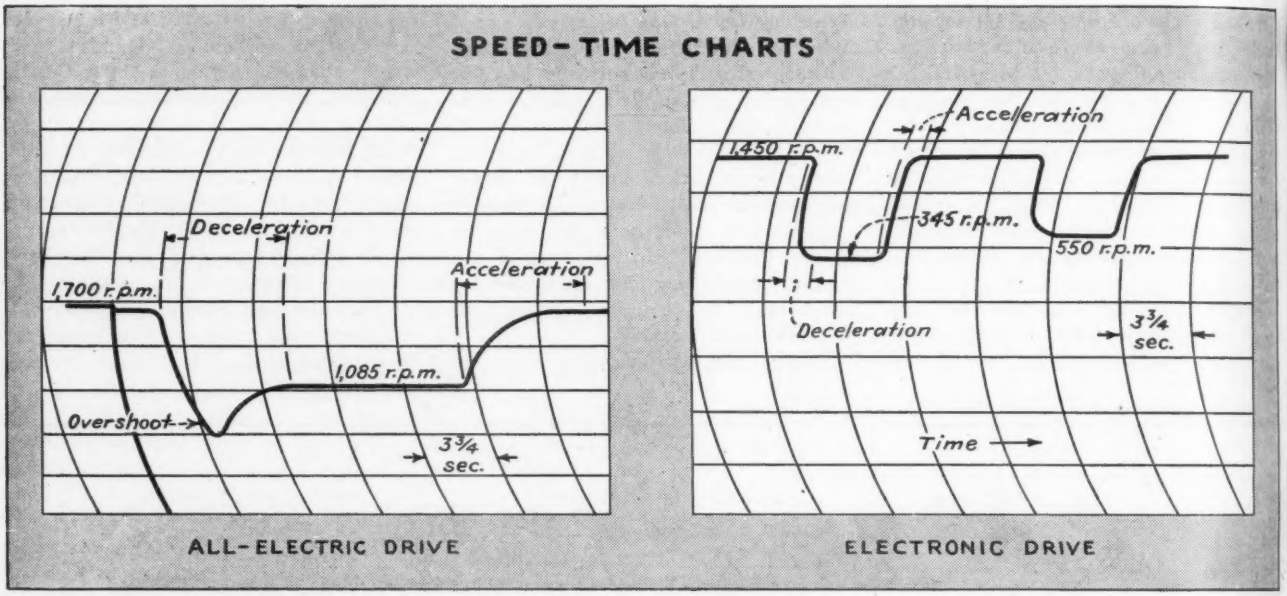
Electrol, Inc.

Fig. 6—Wing lock cylinder with O-ring packings.

All-Electric Versus Electronic Speed Control Systems

J. W. PICKING
Electronic Development Engineer, Reliance Electric & Engineering Company

Analysis of the operating and service characteristics of motor-generator conversion equipment compared with electronic conversion equipment for variable-voltage speed control of d.c. motors.



THE need for a flexible system of speed control led to the development of the Ward-Leonard system, which obtained speed variation by varying the voltages impressed on d.c. motor armatures.

The first step in the present-day utilization of the Ward-Leonard system for individual machine application requiring relatively small horsepower drives was the simplified packaging of the equipment into a compact unit in which a.c. motor, d.c. generator, exciter, and control contactors were mounted and wired. The unit occupies a small space in or separate from the driven machine. Controls are placed wherever desired.

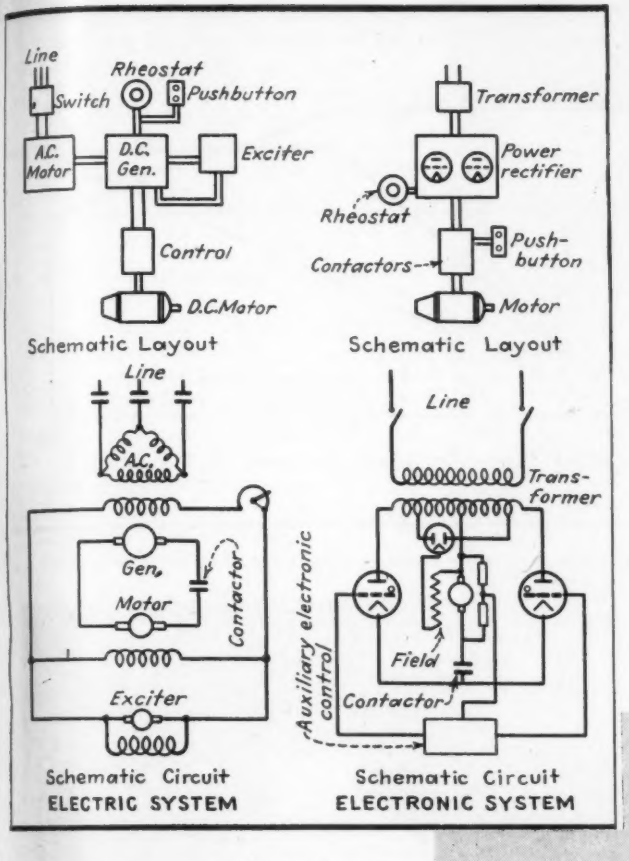
Since the basis of the system involves a.c. to d.c. power conversion and separate excitation, it was a natural development that electronic circuits would be made available as an alternative method of performing these functions. The first development along this line was to utilize a conventional motor generator set but to use a fixed voltage rectifying tube in place of a rotating exciter.

Recently, a complete electronic rectifying circuit has been developed to perform both the functions of conversion and of speed control. Each system has advantages and disadvantages. The rotating drive, in the compact unit now available, actually takes about the same space as the electronic arrangement. However, the electronic controls can be distributed at several points in or about the equipment to which applied and so may actually require less space. Either type drive can be mounted in the base of the machine or at any point near the machine, with the pushbutton and rheostat control located at the most convenient point for the operator.

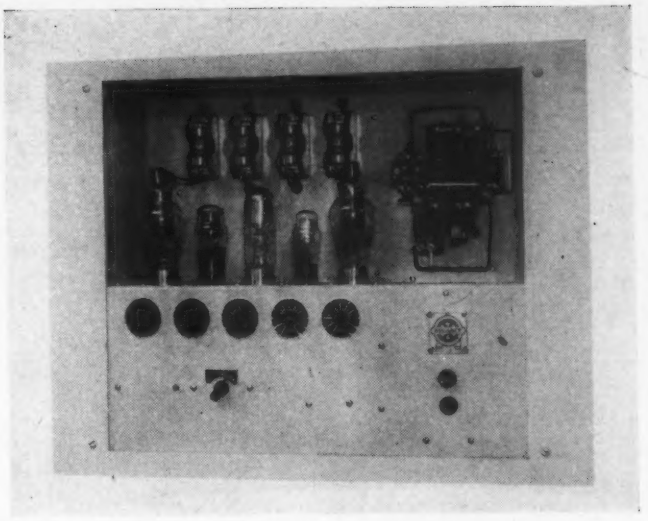
Comparison of Systems

In many respects the arrangement using electronic circuits throughout offers the engineer more flexibility in design because it is possible to separate it into four units: Power rectifier, auxiliary control, contactor panel, and anode transformer. With the rotating system, the motor-generator set must be mounted as a unit. The exciter can be mounted separately if desired, whether it be on a rotating or an electronic unit. Where it is mechanically inconvenient to install the rotating exciter, the electronic exciter is advantageous because it requires no mechanical connection to the motor generator set.

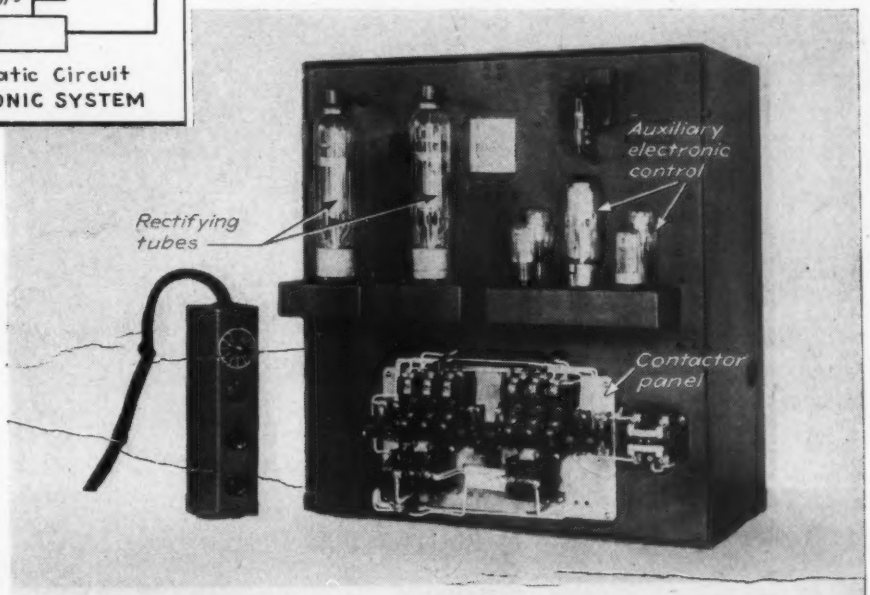
Operating characteristics of the equipment, however arranged, are basically similar. The rotating drive, available in sizes up to 75 hp., has a 20 to 1 speed range. The lowest speed is determined by the amount of residual voltage in the generator. The electronic equipment on the other hand, has no residual voltage, hence lower voltages can be obtained. The speed range of either system can be extended by adding motor field control so that the total range can be four to six times the 20 to 1 ratio. However, for the present, the electronic system is available only in sizes of 5 hp. and below. Speed regulation is much finer with the electronic equipment, although the regulation obtainable with rotating



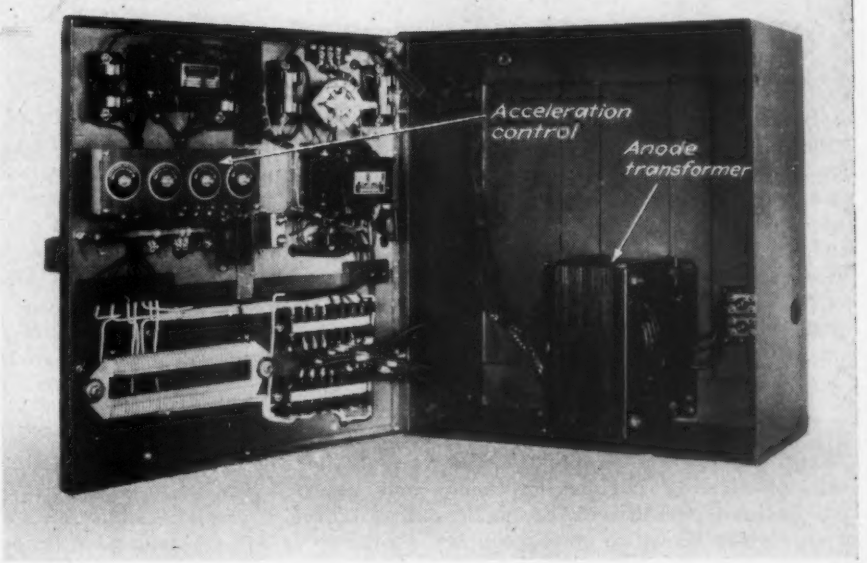
Schematic layouts and circuits for all-electric and electronic speed control.



Electronic program control enables machine operator to pre-set a number of operating speeds. The complete electronic circuit is assembled as a packaged unit to facilitate mounting.

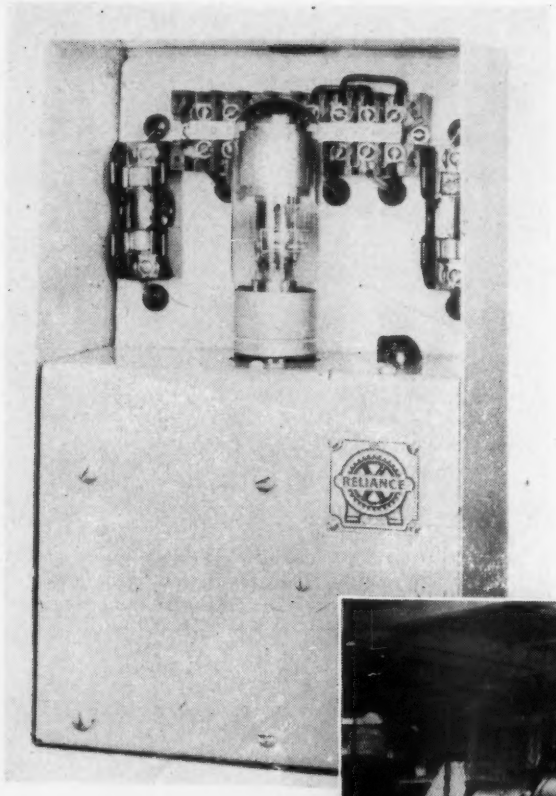


Rectifying tubes and auxiliary electronic equipment is assembled in a compact cabinet unit which can be mounted on or adjacent to the machine.

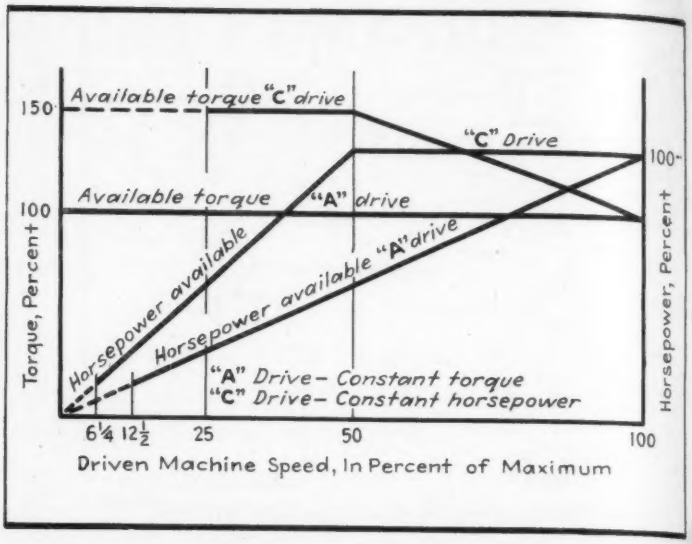


equipment is more than adequate for most applications.

An advantage of the rotating drive is that the system inherently provides regenerative braking on retardation of speed. This type of slow-down is not inherent with the electronic system due to the valve action of the tubes. In cases where quick slow-down is required with the electronic system, a selective dynamic braking system can be added to the electronic unit. Although not as effective as regenerative braking, it will be found satisfactory for most applications. For applications requiring extremely fast acceleration and deceleration between pre-selected speeds, a thorough analysis of both systems indicates that the electronic is better on acceleration and the rotating on deceleration. To obtain the best results, a combination of the two systems has been developed using the rotating equipment for the power conversion, with electronic control. Comparison of the speed-time charts on acceleration and deceleration of a d.c. motor with a rela-



Electronic excitation for all-electric rotating drives is supplied through a fixed voltage rectifier tube, protected by fuses and a 30 sec. warm-up timer in the unit.



Horsepower-torque curves for all-electric rotating drives.

Adjustable-speed control on this precision grinder is obtained by use of remotely mounted electronic circuits which convert a.c. to d.c.

tively high inertia load shows the snap-action of this combined system. To decelerate the rotating drive from 1,700 r.p.m. to 1,085 r.p.m. requires about four seconds due to the overshooting tendency, whereas the combination drive can decelerate under the same conditions from 1,450 r.p.m. to 345 r.p.m. in only a little over one second, and without overshooting.

Methods of Programming

Programming can be supplied with both the rotating and the electronic combination system drives. Any number of speeds can be set up on a group of dials and reproduced accurately and with complete independence of each other. The rate of change from one speed to another can be made as rapidly as the capacity of the motor will permit. Speed selections can be handled with limit switches or similar devices. Although this type of control can be applied to all types of adjustable voltage drives, it is most adaptable to applications requiring a series of adjustable pre-set speeds with automatic or manual selection of these speeds.

Other factors of importance enter into the choice between the two systems. From the cost standpoint, the electronic system may run as little as 15 percent or as much as 100 per cent above that of the rotating system. With the electronic system, only 75 per cent of the d.c. full load rating can be carried continuously by the motor at high speeds, and less than this at very low speeds, because of the increased heating effect of the pulsating rectified current. This pulsating current also causes vibration in the motor which for certain applications may have to be removed by filter, at an additional cost.

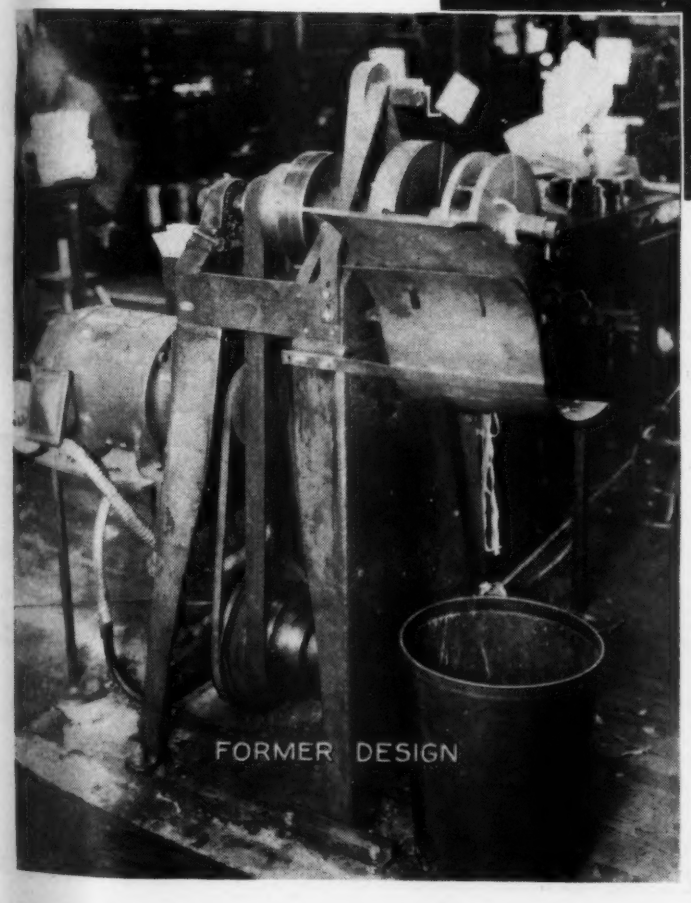
The 45-second warm-up period, insured automatically by a built-in timer, protects the filament of the rectifier tube while still cold against premature application of the load. This may at first

appear to be a drawback to some applications of the electronic type of unit, but the facts are that not only has this warm-up period been successfully reduced from the 5 minutes or more still required by some other electronic devices but is not repeated except as the unit is actually removed from operation at change of shift or by outside power interruption.

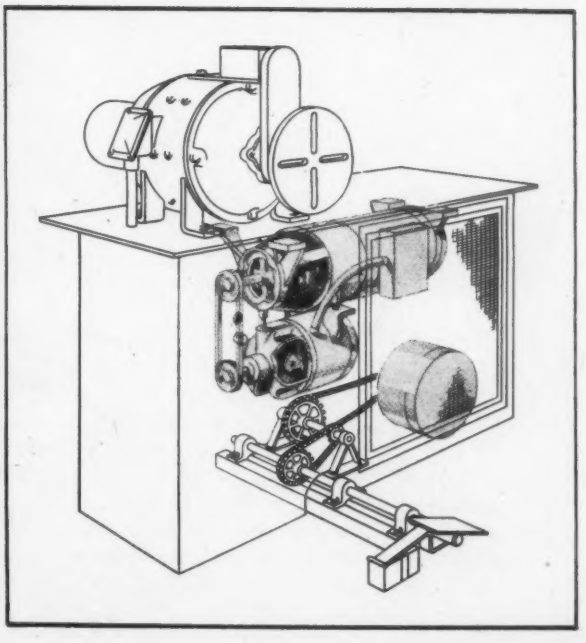
Servicing Requirements

The rotating unit requires lubrication and maintenance of rotating parts while the electronic unit requires servicing by specially trained men and maintenance cost depends primarily on tube life. In dusty atmospheres, the fact that the electronic unit has no moving parts and can be protected by a dust-tight housing is a great advantage.

Selection of the type of variable-speed drive requires an analysis of machine operating specifications, and a study of service conditions and cost factors. In many cases the all-electric drive will satisfy requirements; in others the electronic drive will be more suitable.



Redesign of winding machine, in which starting, stopping and braking are controlled by foot-treadle, utilizes all-electric rotating drive mounted in base.



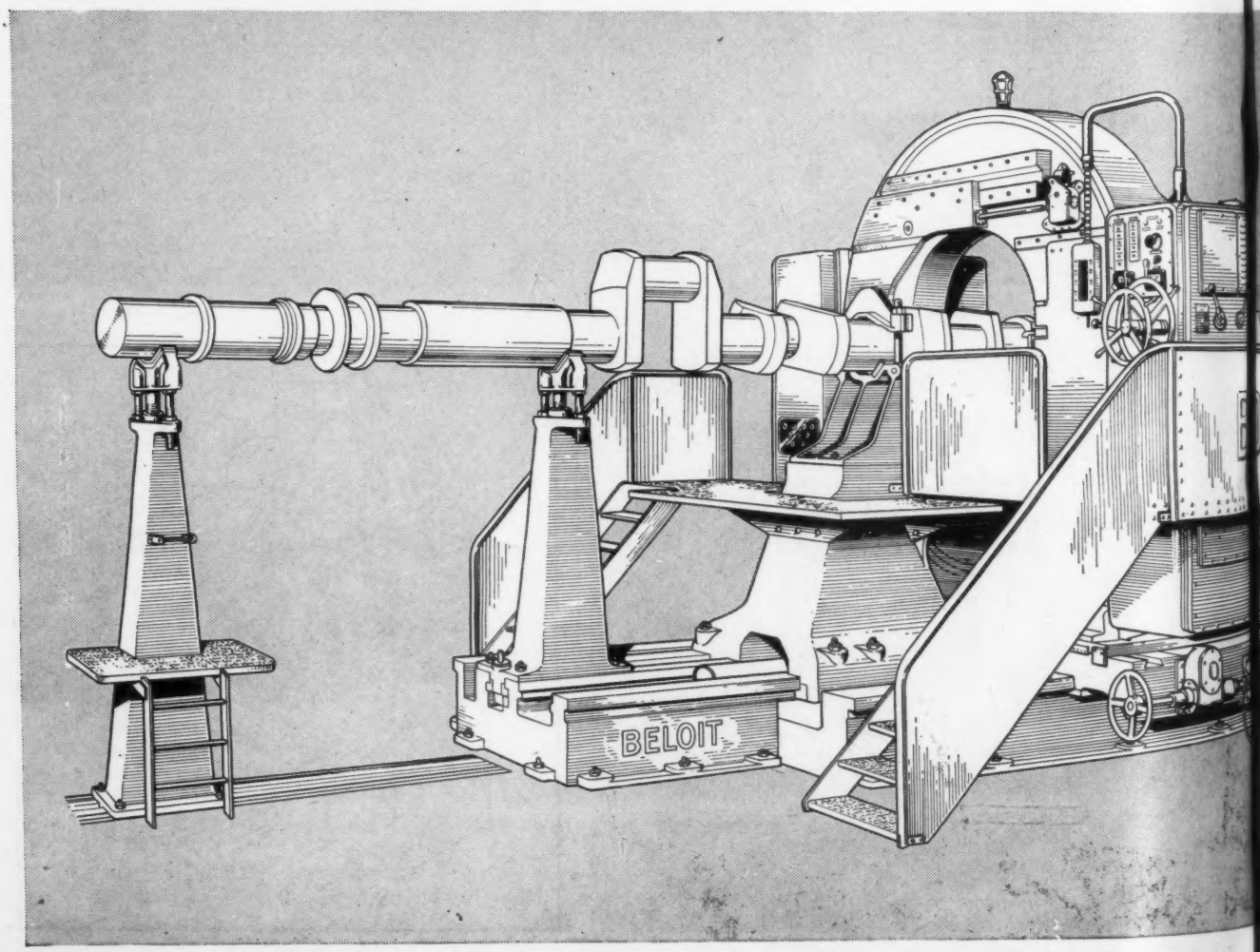
WARTIME DESIGNS

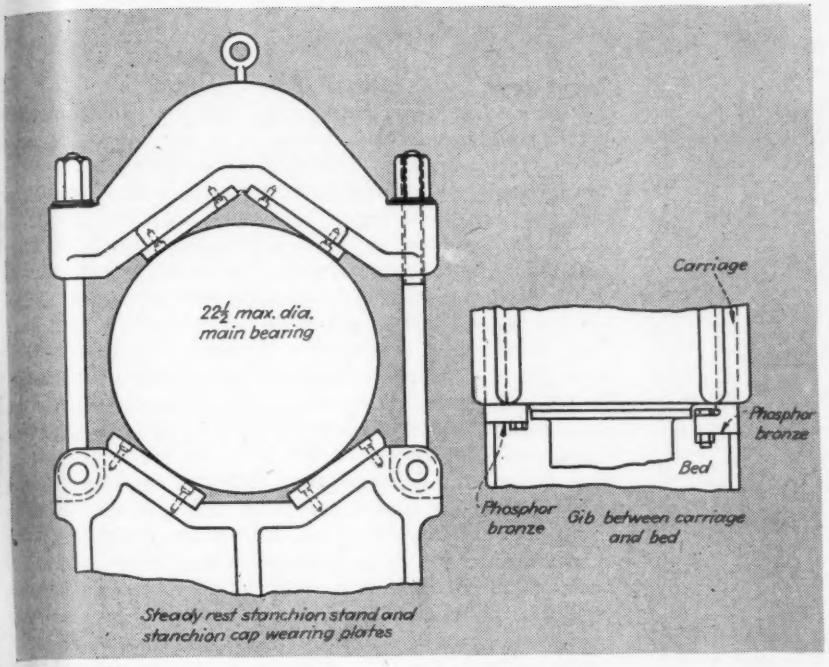
New Lathe Speeds Machining of Crankpins

AT THE beginning of the war there were only a few European built crankpin turning lathes of special design in American plants. Now more than forty crankpin-turning machines, refined and redesigned by Beloit Iron Works, of Beloit, Wis., are in actual operation.

Feature of the design is that the tools are carried around the work which is supported in a stationary position on stanchions. In the conventional engine lathe, the crankshaft must be set-up off center on the center line of the pin diameter Then this large mass must be rotated off-center in order to turn down cheeks, heels and pins. As a result, cutting speeds are low, feed is small because the work cannot be supported rigidly enough to stand heavy cuts without deflection, and it is often difficult to maintain accuracy of centers.

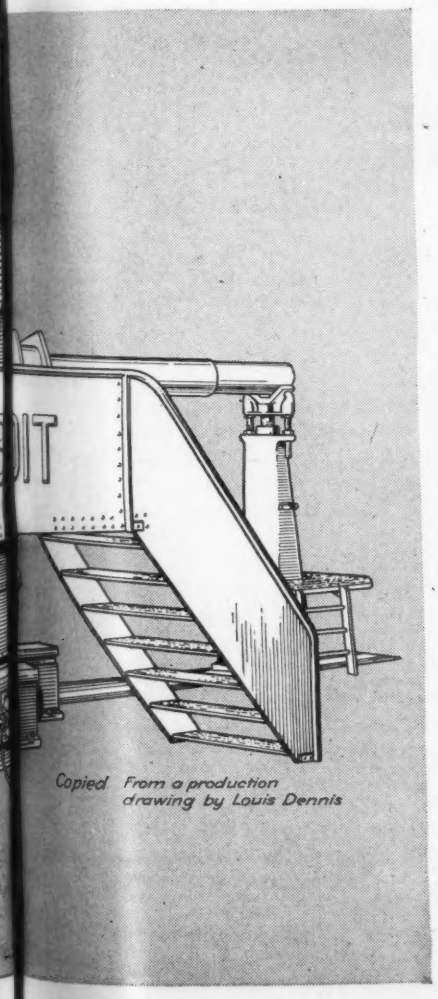
In this machine, the crankshaft is rigidly supported on V-blocks which place the center line of the crankshaft main bearings on the center line of the rotating ring carrying the tools when the stroke is set to zero. To set the stroke the ring housing is moved at right angles to center line of bed an amount equal to the crank throw. The two tools are moved in and out to the required cutting diameter by radial feed. The work is centered accurately by moving the entire ring housing with respect to the carriage, in a direction at right angles to the longitudinal axis of the machine. Wartime demands to reduce machining time and to improve accuracy of cutting of large diesel crankshafts led to the redesign of these unconventional lathes under the supervision of Lloyd Hornbostel, chief engineer of the Beloit Iron Works.



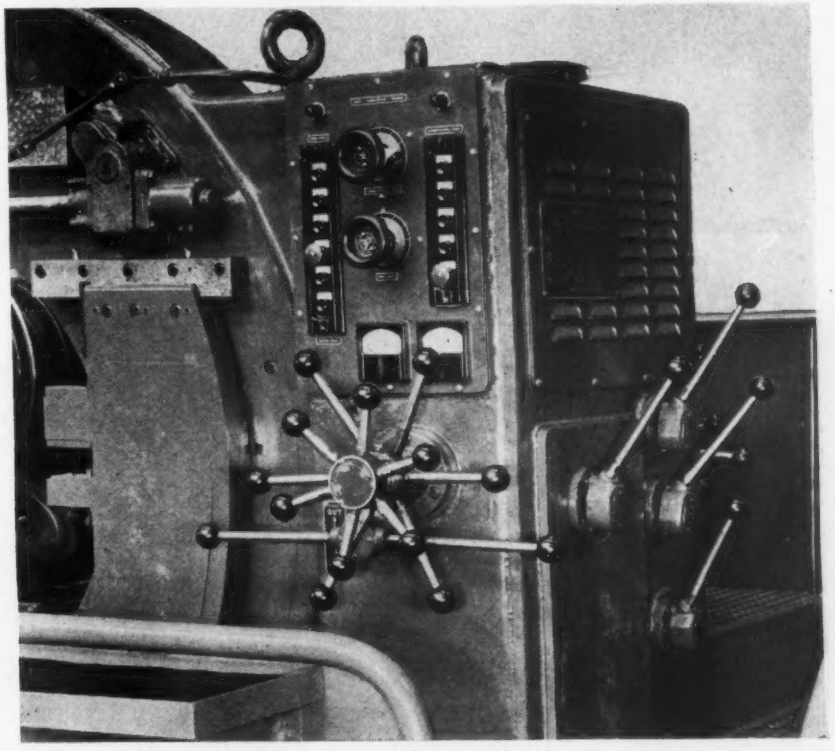


Steady rest stanchion stand and stanchion cap wearing plates

Bed is of heavy construction to insure rigidity. Ways are flat. The outboard steady rests are mounted on a reduced section of the main bed. The stanchions, in which the main bearing journals are clamped during the machining operation, can be fitted with blocks to accommodate various shaft diameters. These blocks are made of chilled cast iron, which is found to wear better than the hardened steel previously used. The main carriage is fitted with adjustable gibs. Moving parts in contact are pressure lubricated by a pump which operates whenever the carriage is moved longitudinally in rapid traverse. Lubricant is not supplied during longitudinal feed cut because oil pressure may build up enough to lift the carriage and destroy axial accuracy in cutting.



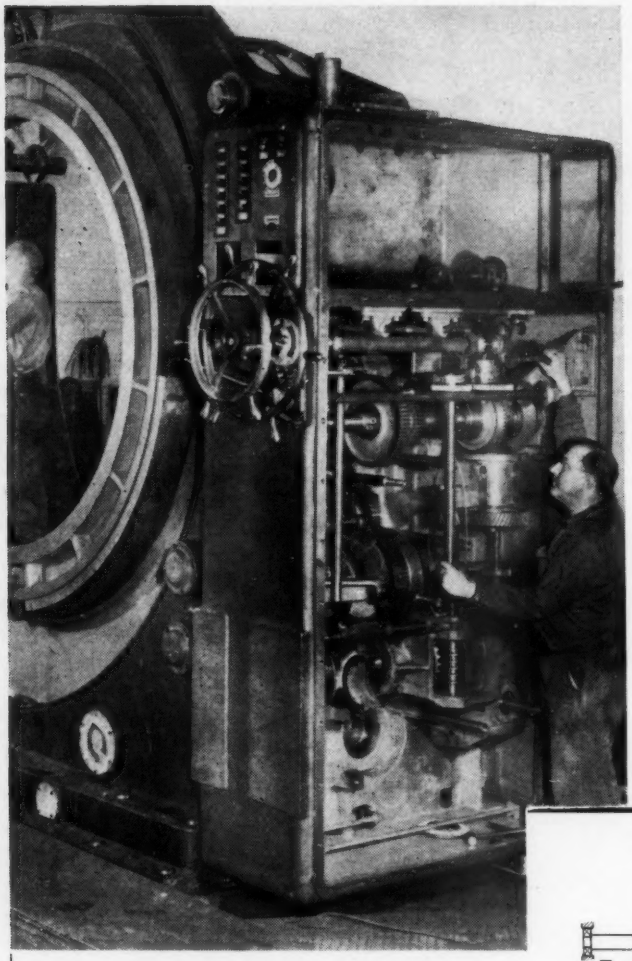
Copied From a production drawing by Louis Dennis



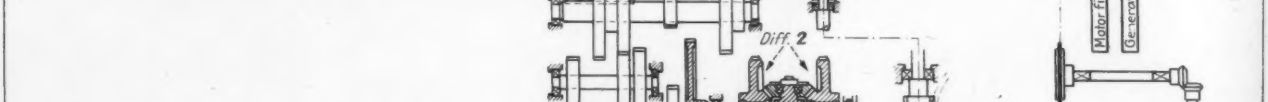
Motor and handwheel adjustment are provided for movement of ring housing on the carriage. Motor, used for traverse, and handwheel, for fine adjustment, are connected to a worm gear and screw assembly. As a safety feature, motor and handwheel cannot be connected at the same time. Gearing and drive equipment is housed at one side of the machine; electrical and lubricating equipment is housed at the opposite side. Thus symmetrical appearance is achieved. Oil gages are placed in the lines to and from the filters, and in the lines to main bearings. The differential pressure across filters is used as a basis for determining when filters need cleaning.

(*continued on next page*)

Crankpin Machining Lathe (continued)

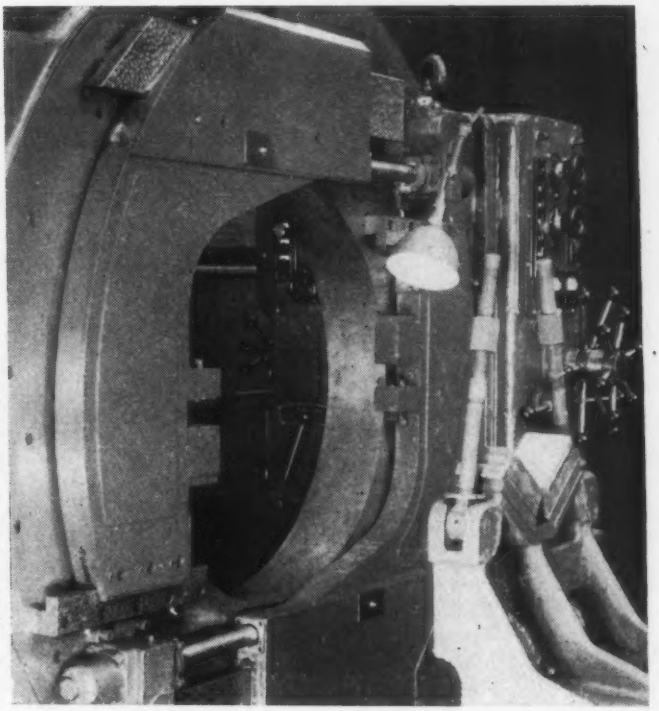


Ring gear is driven by a variable-voltage, motor-field controlled electric drive. Main drive motor is flanged-mounted on the ring housing. Tool holder is mounted on slides bolted to the face of the ring plate. The tool holder is fitted with a nut operating on a radial feed screw driven by a worm gear assembly, which is driven by a spur gear pinion. A slip clutch between the worm gear and the radial feed screw protects the mechanism in case of tool jam. The pinion on the worm shaft meshes with a large-diameter gear mounted on the face plate. This large gear is free to turn in either direction. Power to drive the large diameter feed gear is taken from the main ring drive gear train, through a differential. Ratios and number of gears in the train are selected so that when the center part of the differential is stationary, the large diameter feed gear is driven at the same speed as the ring. Rotation of the center of the differential in one direction causes the feed gear to rotate faster than the ring. Rotation in the opposite direction causes the feed gear to rotate slower than the ring. In this way the tool holder can be fed in and out as required. Definite feed in thousandths of an inch per revolution is obtained by taking power from the main gear train through a series of shifting gears which give eight different output ratios. The output from this transmission then goes through a reversing clutch through a differential. The


Reversing power feed clutch
Cheeking rheostat controls speed of main drive motor
Slip clutch
Motor field rheostat
Generator field rheostat
Diff. 2
Feed gear supported by bearing on faceplate, free to rotate as determined by movement of center of differential 1
Diff. 1
Clutch for disconnecting cheeking rheostat when not wanted for some operations
Radial rapid-traverse motor
Slip clutch
Pin
Fixed brush "F"
Pitch line
Center of differential 1 moves in proportion to tool travel
Proportional to tool travel
Cheek
Moveable brush moves in proportion to tool movement
Changeable plate rotates at face plate speed. Can be changed for different crankshafts if necessary
Tool travel
Pitch line
Crank for adjustment of brush to time with tool position if it becomes out of adjustment due to clutch on tool holder slide screw
Face plate
Main Ring drive motor 30-1 speed range
Area "A" is insulating plate
Area "B" is insulating plate used when both tool holders are used
Area "C" is conducting plate
Drive rotates at speed determined by cheeking rheostat when brushes contact areas "A" or "B"
Drive rotates at fixed high speed when brush "M" contacts area "C."

impact shaft is connected through worm gearing to one side of the differential. The other side of the differential is driven by the radial rapid traverse motor, normally stationary. Either half will drive the center part of the differential, in turn connected to the center of differential one. Purpose of second differential is to eliminate clutches or disconnect gears when combining power feed and rapid traverse. With this combination, the operator can run the tool in under power radial feed and at the same time operate the rapid traverse motor in or out without damaging the equipment. Radial feed can also be operated by handwheel.

Cutting diameter of tool varies widely when crankpin cheeks are machined. Hence with constant r.p.m. of the main ring speed of the cutting tool in ft. per min. at small diameter would be slow. To eliminate this loss in production time, an arrangement was devised whereby the center part of the radial feed differential drives a special rheostat which, in turn, controls main drive motor. Rheostat is so designed that as the tool feeds in, movement of the cheeking rheostat increases speed of ring drive motor so that cutting speed is maintained practically constant. Ratios in this gear train are selected so that rheostat will be moved over the proper portion of its travel, depending on initial cutting speed selected for machining of cheeks by the operator.

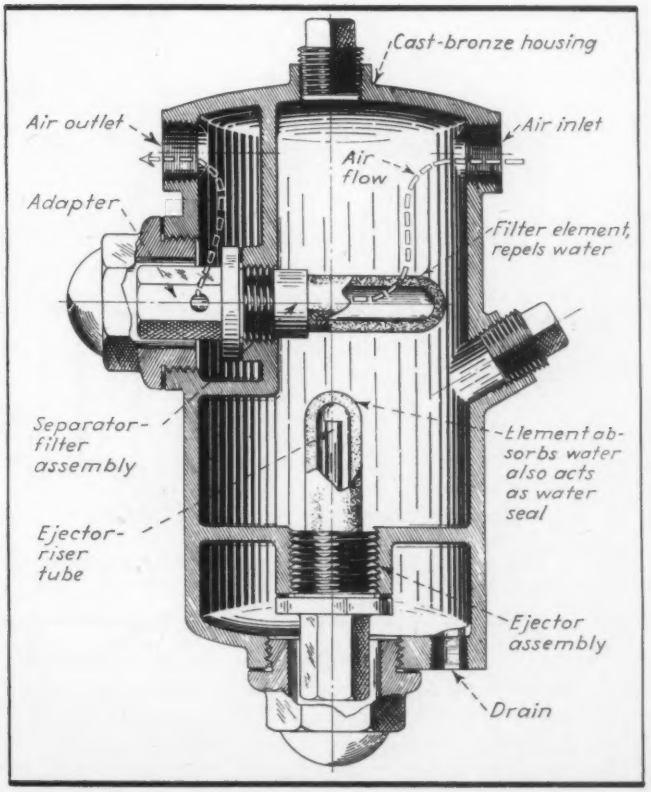


New Principle Utilized in Separating Condensate from Gas or Air

AUTOMATIC AND CONTINUOUS SEPARATION of condensate from gas and air is accomplished without moving parts, traps or shut offs in the new "Liqui-jectors" developed by the Selas Corporation of America. The device is adaptable to air and gas lines up to 1¼ in. pipe size and normal line pressures. Automatic and continuous action is secured by use of two porous ceramic tubes—one inherently water-repellent, the other water-permeable but air-impervious.

Design is based on the method of separating liquid and gas phases by virtue of the surface tension of the liquid. Compressed air entering the Liqui-jector passes through the first water-repellent tube where it is stripped of moisture. The droplets coalesce on the surface of this tube. The tube is a coarse ceramic material with an average of 50,000 pore openings per sq. in., each so small that the pressure drop across the tube is insufficient to permit water passage against the resisting diaphragm-action of the surface tension. The coalesced moisture drops to the bottom of the unit where it passes through the second tube, without loss of air to the outside atmosphere. This second tube is constructed of micro-porous porcelain, with an average of 720 million pore openings per sq. in. Since the tube is constantly wet by its wick action, it constitutes a perfect air seal up to the rated limit working pressure of the unit. This rated pressure may be adjusted to user specification.

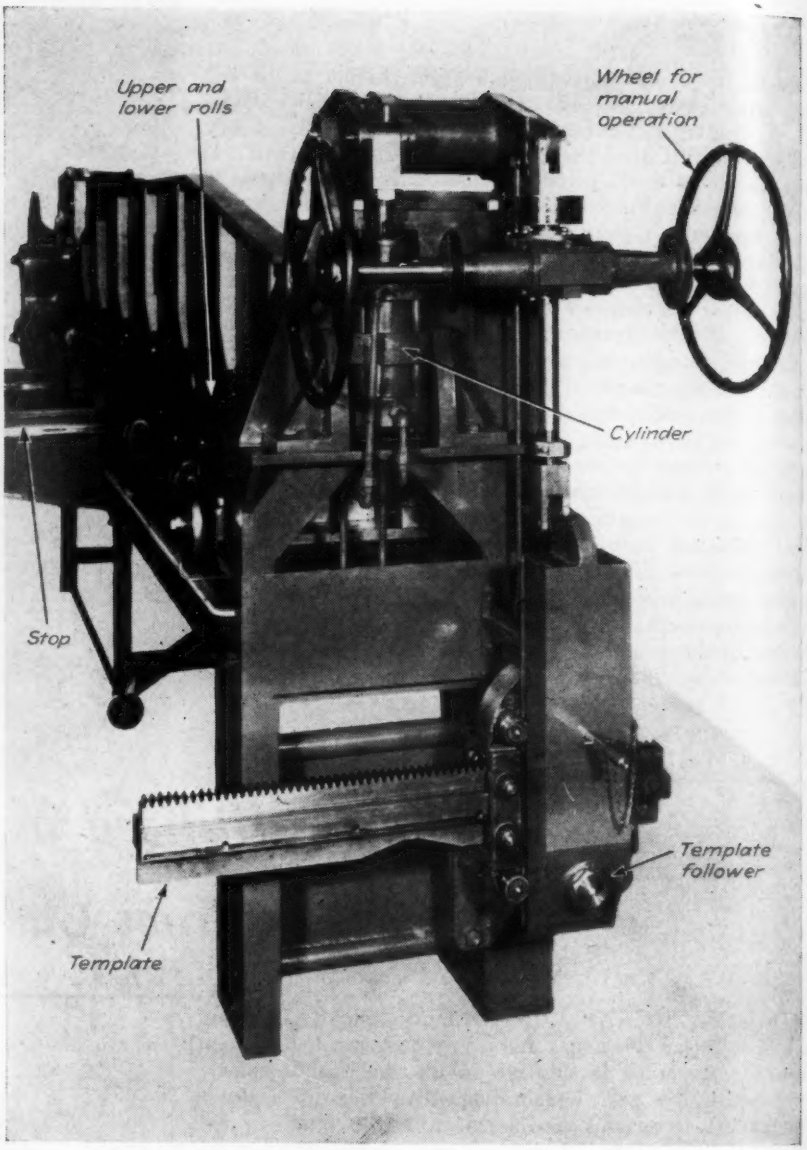
The physical design of the unit in oval shape permits flush-against-the-wall installation, directly in the line, without the addition of elbows or other fixtures. Servicing of the unit is facilitated by several access openings.

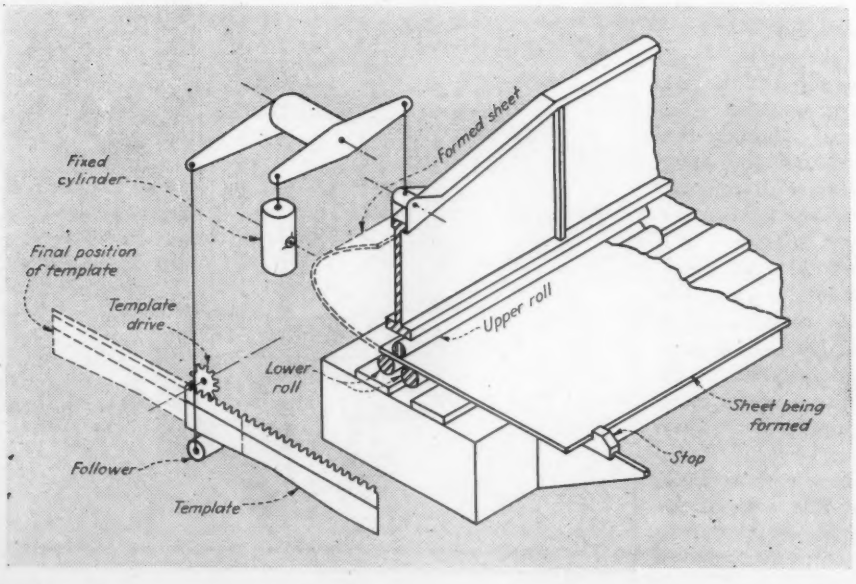


Templates Guide Forming Rolls

ALUMINUM alloy sheets 1/16 in. thick and up to 15 ft. long can be formed in one pass to a minimum radius of 1¼ in. in the new Farnham Forming Roll designed by Paragon Research, Inc., Since templates guide the machine, skilled labor is not required. Change of dial setting and reversal of rolls is eliminated in the forming operation.

Upper roll movement is controlled by templates at each end of the machine. Hydraulic pressure holds follower against template. All three rolls are bronze. They are electric motor driven to provide positive feed of work. Drive to rolls is through universal joints. Links and levers are roller bearing mounted.

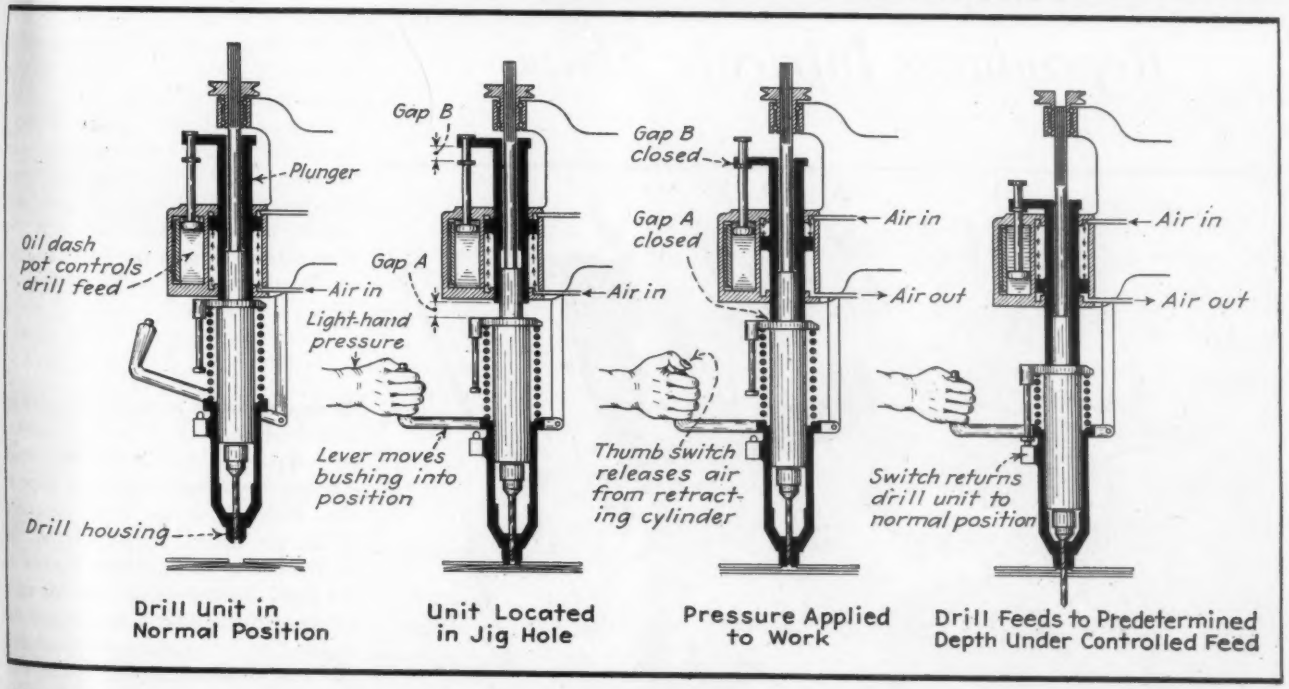




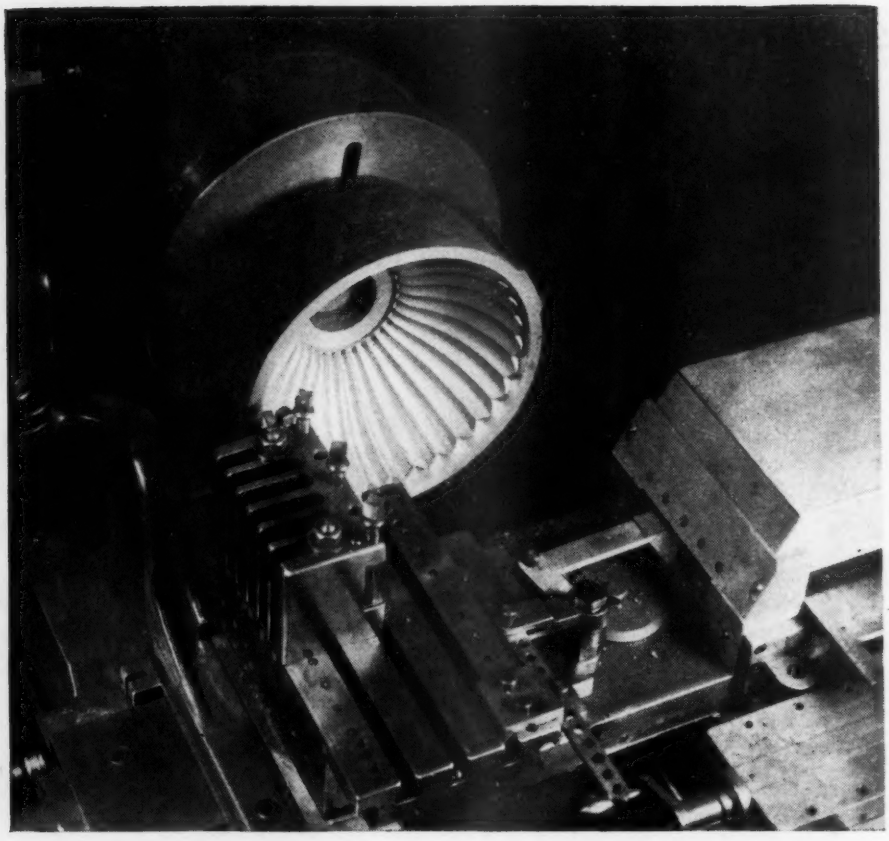
Schematic of operation. Flat sheet is inserted between upper and lower rolls, and against adjustable stops. Oil is admitted to cylinder by operation of manual valve, lowering upper roll and at the same time raising template follower to contact template. As upper and lower rolls revolve, sheet is fed through. Pinion drives template, raising or lowering upper roll to form sheet to desired contour as determined by template.

Drilling Unit Cycles Automatically

DRILL approach, feed and return are obtained automatically in the high-speed carriage drills developed by Paragon Research for the Farnham Manufacturing Company. Designed for production drilling of spars, wing panels and other long assemblies, the drill unit can be mounted in either horizontal or vertical position. Drill is fed by spring pressure and returned by air pressure. Slow feed is governed by adjustable dashpot. A single handle with inbuilt pushbutton controls the entire operation. Drive to drill is by V-belt from a ½ hp. motor. Provision is also made for high-speed emergency retraction of the drill.



Air pressure holds plunger in up position. As drill unit is located in jig hole manually, drill and bushing move together to form gap *A*. When thumb switch is closed, air pressure is released from bottom of cylinder and admitted to top and plunger moves down at fast speed until gap *A* and gap *B* are closed. When gaps *A* and *B* are closed plunger slows down to drilling feed, controlled by dashpot, and hole is drilled to proper depth. Limit switch mounted on drill housing returns unit to normal position whether thumb switch remains closed or open.



Automatic Machine Reproduces Intricate Shapes

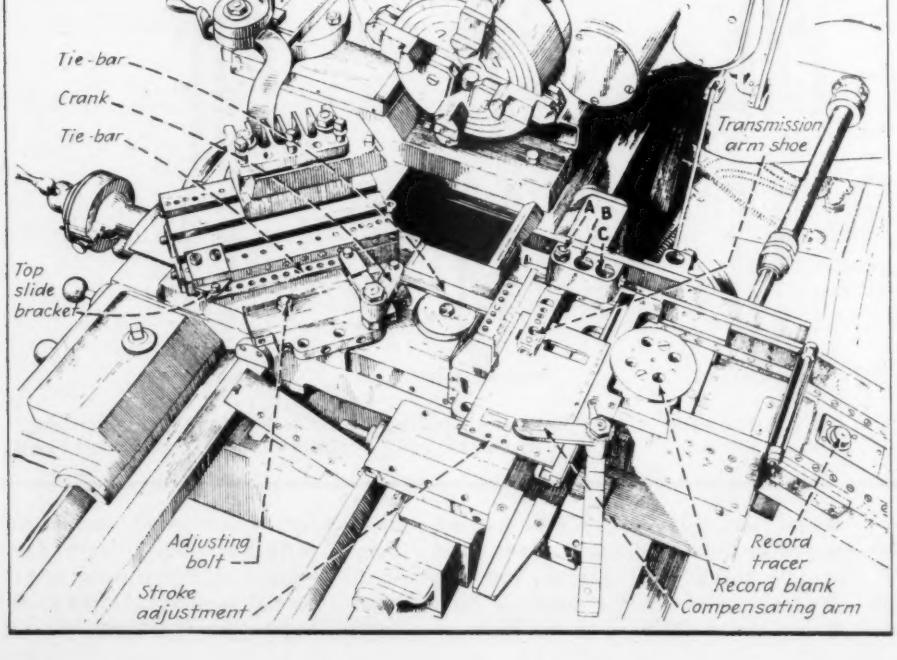
THE tool-actuating mechanism in the new Monarch lathe is cam-operated and mounted on the carriage crossbridge in place of the usual compound rest. A cam follower is linked to the movable tool carrier, which is mounted on anti-friction bearings, and guides the tool in a shaper-like stroke which is adjustable from 0 to 2 inches.

Repetition of the shape to be cut is determined by the geared relationship of cam and spindle. A single motor powers both, and the machine has change gears which give a range up to 500 tool actuations per revolution of the work.

The over-all contour of the work can be varied in two ways. A stroke-compensating device maintains the same surface shape as diameter of the work piece increases or decreases. Irregular contours can be obtained by the use of a metal template in conjunction with Keller electrical controls.

Shape generation has been simplified through the arrangements for making the necessary master record cams. A motor-driven cutting head is substituted for the tool. Operating at reduced speed, the machine cuts its own cam.

Any shape may be turned, faced or bored. Straight line motion is provided to the tool slide at any angle from 0 to 90 degrees (right angles) to the lathe axis. Between the cam follower and the tool slide a transmission slide has been provided which permits adjustment of the stroke from zero to the full capacity of the machine.



Transmission arm is generally set in hole *A*, but it may be set in any of the three holes, depending upon whether the outside or inside edge of the work is to be held constant. When the arm is in position *A*, the movement is straight line motion to the right. Therefore, the outside edge of the work is held constant and the inside line is variable. In position *B* the arm moves an equal distance on each side of center, and both inside and outside edges of the work are variables. When the arm is in *C* the inside edge of the work is constant and the outside a variable.

Fibrous Glass Insulates 18,000-Hp. Motor

FIBROUS GLASS is used as covering for the strands within the conductors in an 18,000 hp. Westinghouse motor built for Boeing Aircraft Laboratories. The glass subdivides the conductors so that certain eddy losses are kept to desired minimums. Glass is used as the outside binder for all phase and lead connections. It is used as a high-temperature binder for the coil, where, because of its resistance to corona attack, it also serves as a base for semi-conducting treatment for the elimination of corona. The 18,000 hp. motor drives a multi-bladed, propeller-like fan which creates an air stream with velocities up to 700 miles an hour, for testing performance of model planes and plane parts.

Plastic Light Of Watertight Construction

TAPERED PROJECTIONS molded on the side walls of lens and end caps press down upon small rubber washers inserted between the body and the caps to provide watertightness in this Navy flashlight. The compression thus obtained and held by thread construction prevents water seepage. Water cannot enter the light at the metal switch, which is connected

Tennessee Eastman Corporation

by poles molded into the plastic. The switch mechanism has three positions—flash, steady, and lockoff. The end cap is ribbed for screwing and unscrewing. The Navy flashlight was designed by Fulton Manufacturing Corporation, in cooperation with Navy engineers, and molded of cellulose acetate-butyrate by Reynolds Molded Plastics Division.

Plastic Cam Useful for Motion Analysis

IN THE ANALYSIS of complicated cam-controlled linkages and motions for new machines, United Shoe Machinery Corporation engineers have found model linkages mounted on a flat board helpful. According to W. C. Goodchild, a simple method of making a closed face cam to control the motion of the linkage is to lay out the desired cam with a scratch awl on a thick piece of transparent cellulose nitrate or acetate sheeting. Since this material breaks easily on any scratched line, the inner and outer cam track can be made from the same piece. The edges of the track are sanded to provide 1/16 in. clearance for a thumbtack follower. A spacer and back surface of the same material can be used and the part assembled with pyroxylin cement. The linkage is attached to the thumbtack follower so that rotation of the cam moves the linkage through its cycle.

Rubber Replaces Wood in Batteries

MICROPOROUS, WAFER-THIN RUBBER is now replacing wood in storage batteries. The material, developed by scientists of the United States Rubber Company, has millions of tiny cells per square inch. Unlike wood it does not buckle when the protecting acid and water mixture becomes low or completely expended. With rubber separators the battery can be completely charged at the point of manufacture and shipped without liquid. This is accomplished by charging, removing mixture, drying plates and resealing the battery. Batteries thus treated retain 75 percent of their original charge after a year's storage.

High Tensile Wire Wrap Prevents Bursting of Cylinders

INGENIOUS NEW METHOD of preventing deadly "shrapnelling" of the oxygen and carbon dioxide cylinders used for breathing and fire-fighting purposes aboard U. S. planes has been developed by engineers of Walter Kidde & Company. Because of high internal pressure, untreated cylinders can explode into pieces of shrapnel-like flying steel when hit by flak or enemy machine gun bullets during combat, and the fragments can riddle the fuselage of a plane. The new process consists of wrapping each cylinder tightly with high-tensile steel wire. Bullets leave a clean hole with no fragmentation.

WARTIME DESIGN NEWS

Weapons Review

THE UNITED STATES has robot planes "far in advance of anything the enemy has disclosed," according to Maj. Gen. Bennett E. Meyers, commanding general of the AAF Material Command, who added that the robot bomb is "strictly a defensive weapon and we don't need it now."

As the drive off the Normandy peninsula and into France proper gained headway, Maj. Gen. Harry B. Sayler, chief ordnance officer of the European theater, partially disclosed a new weapon. Gen. Sayler said the allies have a gun the range of which is so great that the usual low speed observation planes—light-weight Cubs and similar planes—are useless as "eyes" for the new gun. Regular fighters will be used instead, Gen. Sayler revealed.

The Eastman Kodak Company has gone into large-scale production of the M-76-C tank telescope which enables a gunner to pick out a target a mile away. The 30-in. telescope sights a 24-deg. field magnified three times. Its lenses are made of a sand-free, rare-element glass, and the telescope is so mounted as to remain on the target despite bouncing by the tank. This mount presumably is similar to one employed to stabilize tank artillery.

Extra protection for combat air crewmen is being provided by flak curtains hung inside both heavy and medium bombers. The curtains are made of the same link-connected steel plates which are used in the flexible body armor worn by these men. They will cut down the number of shell fragments which can reach the crew members.

British "Shotgun" Bombsight

The British have come up with a new bombsight which, while not attempting to give the pinpoint accuracy possible with our Norden bombsight, allows a bomber to dump its explosives while taking evasive action rather than requiring it to hold a steady course.

Known officially as the T-1 sight, and manufactured on a mass production basis by General Motors' AC Spark Plug Division, the sight is used extensively by British night bombers. It achieves a shotgun pattern which is depended upon to blanket the target.

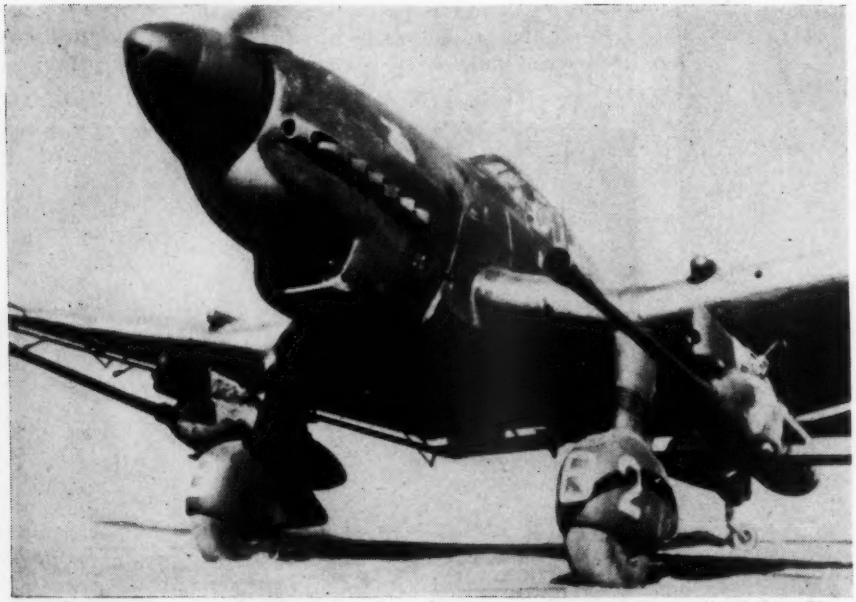
Extensive redesign has lightened the AC sight by 30 lbs. from the British original. It incorporates heavy-pressure aluminum castings, rubber wheels and plastic cams. It is built in two units, one a mechanical computer, the other a telescopic sight. The bombardier sights the target with one eye through the telescope and releases his bombs when two cross hairs, visible through the other eye, cross over the target. Variations of the plane's course are compensated for by two gyros, one measuring the plane's pitch, the other its roll.

Skin Dressing for Tanks

Nazis are trying to beat Allied "sticky bombs," explosive charges coated with heavy grease or other adhesives to make them stick to a tank hull while they burn furiously, by mounting slick plastic hulls on their 60-ton Tiger and Panther tanks. The plastic hulls are camouflaged a gray green, and are supposed to shed "sticky bombs," numerous varieties of which have evolved from the original Russian "Molotov cocktail," a bottle of gasoline and oil with a cloth wick and a coating of lubricating grease. The Panther is a refinement of the German 60-ton Tiger.

The one-ton "doodlebug" robots which have been showered across the

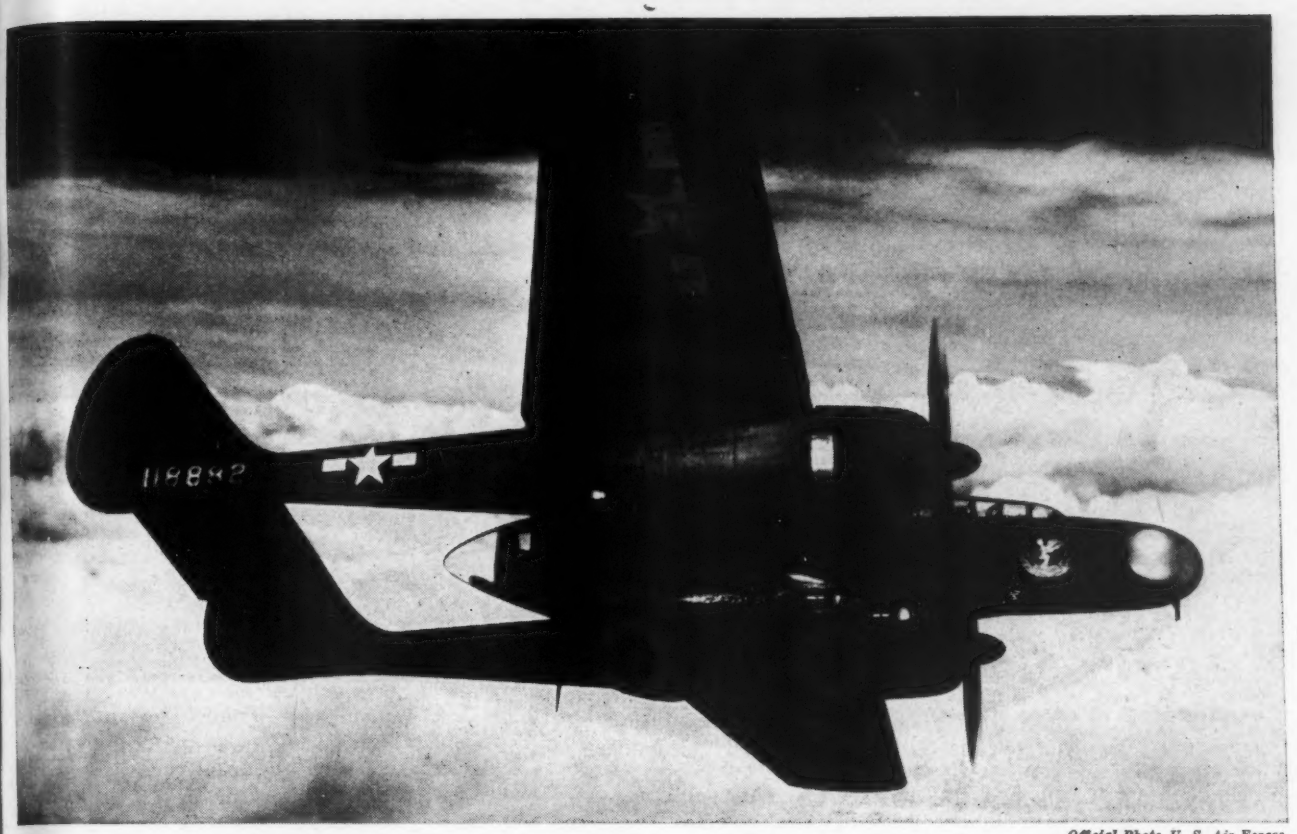
JU-87 Drafted As "Tank Buster" by Nazis



International News Photos

Recalled from behind-the-lines service to which its type was relegated some time ago, the German Junkers JU-87 has been pressed into service as a "tank buster" similar to the American P-39 "Airacobra." Slung beneath the wings are two nacelles from which protrude twin cannon. While caliber of the guns is unknown, they probably are at least 37-mm. weapons, since that is about the smallest caliber cannon which can be effective against tanks. The Germans some time ago were using similar nacelles mounting six light machine guns for ground strafing. With one nacelle, somewhat longer than those shown here, swung under each wing by a flexible one-point suspension, the Nazis were able to mount tremendous firepower against compact targets.

"Black Widow" Designed Specifically for Night Fighting



Official Photo U. S. Air Forces

Northrop's P-61 "Black Widow" night fighter plane is the first ever designed specifically for this job. Design of this plane was started shortly after the Battle of Britain demonstrated the need for a plane which can handle bombers raiding at night. The ship is built around detection equipment which locates the enemy. Its firepower is tremendous, including 20-mm. cannon and .50 cal. machine guns. Four-blade propellors and favorable wing loading contribute to an excellent rate of climb. Power comes from two double Wasp engines of 2,100 hp. each, which are fed from large built-in gasoline tanks and extra-size disposable tanks. New type ailerons lend handling ease, and full span flaps make landing relatively easy. For night interceptor operations, special ground-controlled equipment is used to give vectors, or directions, to the pilots which will bring them fairly close to the enemy. Then the ship's detection equipment is used. The crew member operating the equipment gives firing orders over the interphone.

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channel by the Germans are simple in design and construction, according to experts, being made principally of sheet metal and adaptable to production in small shops. The jet engine which propels them is a masterpiece of simplicity, according to some observers. A single spark plug ignites the first charge, and each successive charge is ignited by its predecessor. Spring-controlled shutters admit the proper amount of air and are closed by explosions in the engine.

Military Research Set-Up

THE COMMITTEE appointed to work out a program for postwar military research (PRODUCT ENGINEERING, August, 1943, pp. 520-521), which had held three meetings by August 1, hopes to evolve a plan under which scientists, educational institutions, industries and others interested in research can cooperate with the Army and Navy in advancing ideas and research on military subjects, with the services free to take ideas to these sources for consideration. The committee is known to be looking to appropriations by Congress for the financing of postwar military research, and its work thus far has partially evolved a "bold and ambitious program." Charles E. Wilson, executive vice-chairman of the War Production Board and a leader in the establishment of the committee, is chairman.

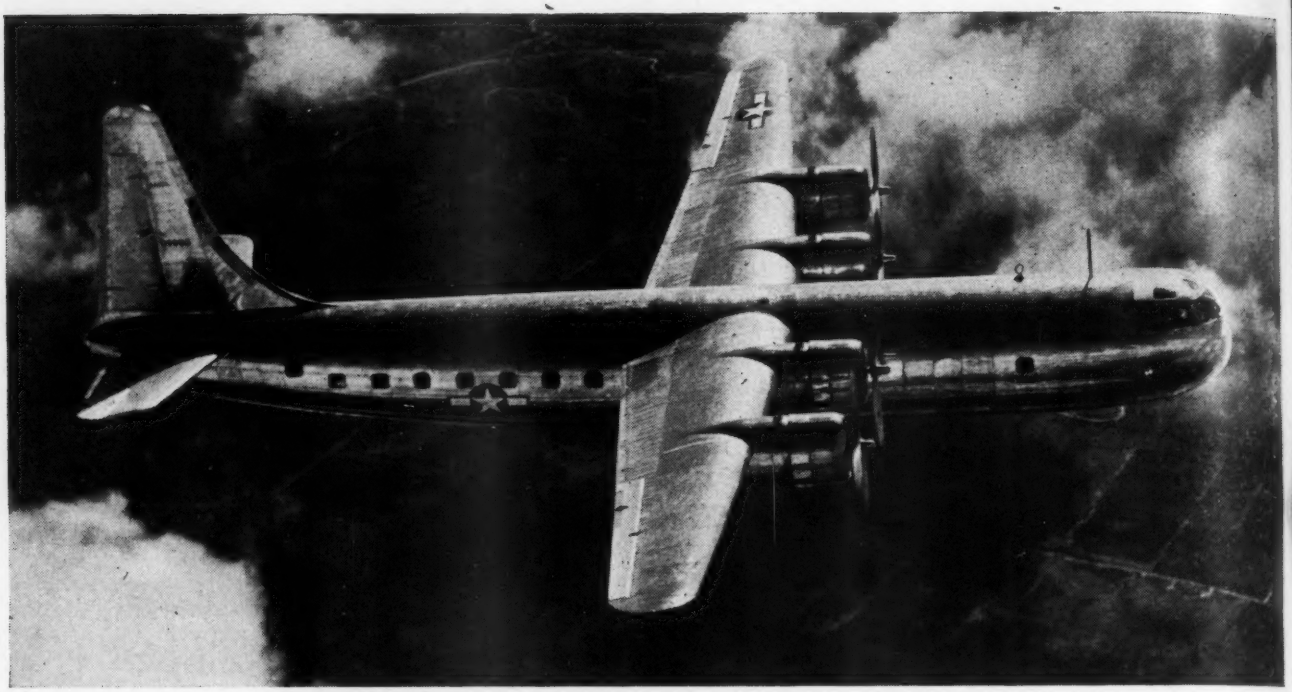
The problem is under consideration from another government quarter, for the forthcoming draft of a bill for scientific mobilization, as yet undisclosed by its author, Sen. Harley Kilgore, West Virginia Democrat, contains a section on postwar military research. Kilgore's primary interest lies in making available to small businessmen the scientific knowledge which he says has been too centered in large corporations.

Better Aircraft Materials

RESEARCH and development on materials for aircraft now carried on by the government, the aircraft industry and material producers will be coordinated by a committee appointed by the National Advisory Committee for Aeronautics. The new group is expected to avoid duplication in aircraft material research programs which have been stepped up since the pressure on plane production began to ease some time ago.

The committee also will attempt to lay the groundwork for future development, in cooperation with the recently established committee on postwar military research. NACA, Army Air Forces, Navy's Bureau of Aeronautics and coordinator of research, Civil Aeronautics Administration, Office of Production Research and Development and the National Research Council are represented on the committee thus far. Research

Commercial Transport Plane Based on "Liberator" Bomber



Consolidated Vultee Aircraft's version of a post-war commercial transport plane is this Model 39, which combines the B-24 "Liberator" bomber wing, power plant and landing gear with a specially designed fuselage. The famed twin rudders of the "Liberator" have been discarded for a single high rudder and vertical fin. Civil Aeronautics Administration officials are known to be sceptical about the plane's commercial possibilities as long as the B-24 wing is used. Powered by four 1,100-hp. Pratt & Whitney engines, the plane would have a normal operating range of 2,500 mi. and a maximum range of 4,000 mi., with a cargo payload of 12,000 lb. Cruising speed is 240 m.p.h. at 60 percent power. Forty-eight to 52 passengers would be carried, or 24 if it is used as a sleeper plane.

units of the Aircraft War Production Council and other industry agencies will be added later.

NACA's Dr. George W. Lewis is chairman, and Lt. O. C. Roehl, of the Navy's Office of Procurement and Materiel is temporary executive secretary. The committee will compile, distribute and maintain a list of projects under investigation. It will receive information relative to specific aircraft supply problems and will recommend disposition of such problems. Also, the committee will receive and transmit information from abroad.

New Ordnance Developments

A NEW OIL for recoil mechanisms of Army artillery has been developed by the Ordnance Department, enabling one oil to replace seven types formerly required. The new oil can be used in all weapons in atmospheric temperatures ranging from —30 deg. to 125 deg. Additional uses are being explored by the Ordnance Department for the new oil, known as "808," in an attempt to lighten further the supply problem.

At Fort Benning, a civilian ordnance foreman, Ray Miller, had been cited for exceptional service in perfecting a rifle-grenade launcher which allows the launching of grenades from the M-1 Garand semi-automatic rifle. The M-1 bolt is operated by a gas-actuated piston and no successful method of preventing operation of the bolt when a rifle grenade was fired was available until Miller's invention proved reliable. Model 1903 Springfields were issued as standard equipment to several men in each infantry company to provide for launching of rifle grenades. Miller's launcher, an early model of which was destroyed in testing, injuring him severely, prevents gasses generated by the powder charge from operating the M-1's bolt. The invention allows the discharge of anti-tank grenades, hand fragmentation grenades, the old-style "pineapple" grenade and about 30 signal grenades.

Army Supply was further simplified by the Ordnance Department's development of a single standard lubricating fitting which can be used on all mobile vehicles, including tanks, trucks, anti-aircraft weapons and field artillery. The new fitting eliminates almost 20 different fittings and 5 different types of couplers.

Signal Corps Saves Rubber

USE OF SYNTHETIC and alternate materials enabled the Army Signal Corps to save more than 12,000,000 lb. of crude rubber during the first four months of this year. As a result, monthly Signal Corps requirements for crude rubber have dropped from 2,626,000 lb. in June, 1943, to about 800,000 lb. in April, 1944. Further changes in design and production techniques are steadily decreasing the use of rubber in Signal Corps equipment.

Largest savings have been in field wire and telephone cable assemblies. Equipment such as handsets, headsets, terminal and connecting blocks, vibration-resistant mountings, testing gloves, jacks, battery jars, microporous separators, rubberized fabrics and thousands of other items have been under study since the rubber shortage became apparent. These studies are being continued wherever feasible to improve the products or to conserve more rubber.

Exploding the Myth About Postwar Models

MUCH publicity is being given to claims that the civilian goods to be produced immediately after reconversion will be prewar models. Visits to manufacturing plants and interviews with executive engineers do not substantiate this viewpoint. On the contrary, innumerable new designs of durable consumer goods are waiting for production lines to begin moving.

The new designs are definite improvements over the prewar models and some are far superior. A few represent products that were virtually unobtainable before the war. This situation applies also to postwar industrial equipment and production machinery.

Specifically, a manufacturer of refrigerators has a working model of his improved postwar unit and a complete layout of the necessary production lines. He is ready to start production as soon as material and labor are available. Another manufacturer has a snappy line of electrical appliances set up for inspection in the inner sanctum. The new models appear much different from their predecessors. Still another company is prepared to produce a full line of low-temperature freezing boxes for home use.

New models of television sets, far superior to those developed before the war, are ready for production so that they can be placed on dealers' shelves with all possible speed. Even the first automobile to be built after reconversion will be appreciably different from the 1942 models.

It is only logical that a minimum of prewar models will be made. Much of the 1941 production machinery is useless. It has become worn out from overtime operation on war goods. Much of the machinery placed in storage has become obsolete. Improved machine tools will compel the reequipping of factories, and it would be silly to make new installations for the manufacture of prewar models.

Naturally, manufacturers are not shouting loudly about their postwar designs. They prefer to speak about them only in vague terms. But each one is straining at the bit, all ready to go in the strenuous race to be the first to get his smart new stuff on dealers' shelves.

Any chief engineer who is taking it easy because he is counting on a breathing spell to give him time to finish his postwar models is in for a rude awakening. There will be no profits for the company left at the starting post.

G. F. Rodenhold

AGMA Standard for Lubrication Of Enclosed and Open Gearing

Part I—General

SECTION I—SCOPE

1. This standard covers the method of lubricating and the type and grade of oil to be used in enclosed gear drives and open gearing. It is applicable to the following types of gearing:

Helical	Straight Bevel	Worm	Spur
Herringbone	Spiral Bevel	Hypoid	

An appendix AGMA standard 250.01A showing a typical list of gear lubricants by trade names has been prepared by the American Gear Manufacturers Association. Other oils meeting the specifications of grade and viscosity may be substituted.

SECTION II—LIMITATIONS

These specifications apply only when the gears are designed and rated in accordance with AGMA standards. The ambient temperature range for which they apply is from 0 to 150 deg. F. Gear drives operating outside of this range or those operating in extremely humid or chemical-laden atmospheres should be referred to the gear manufacturer or lubricant supplier for his recommendation.

SECTION III—LUBRICATION OF GEAR TEETH

The areas of contact on gear teeth are relatively small and the unit pressures produced in transmitting the loads are relatively high. It is therefore essential to provide a film of lubricant of sufficient strength to withstand the localized pressure during the period of contact. The peripheral speed of the gears governs the period of tooth contact and determines the length of time the film must withstand the pressures. When speeds are high, the time is very short and the loads are usually light and as a result an oil of comparatively low viscosity should be used. When speeds are low and the loads heavy, the contact time is considerably longer and an oil of higher viscosity should be used.

SECTION IV—TEMPERATURE

1. The ambient temperature, which is here defined as the temperature of the air in the vicinity of the gears or gear unit, has considerable bearing on the viscosity of oil to be used. In general, the viscosity of mineral oil varies inversely with the temperature, which fact makes it desirable to use an oil of heavier grade at high ambient temperatures than would be used for the same application operating in a low ambient temperature. Also, for low temperatures an oil must be selected which has a pour point lower than the minimum temperature expected for the application.

2. Where the operating temperature for any one application varies more than 80 deg. F., a viscosity index (Dean and Davis) of 60 minimum is desirable. For ordinary applications, a viscosity index of 20 minimum is satisfactory.

SECTION V—TYPE OF OIL

1. Lubricating oils for use with gears and gear units should be high grade, high quality well refined petroleum oils. They must not be corrosive to gears, or to ball, roller or sleeve bearings; they must be neutral in reaction; free from grit or abrasives; and have good defoaming properties. For high operating temperatures they must have good resistance to oxidation.

2. Lubricants of the straight mineral type are to be used for all except worm and hypoid gears. For worm gears, additions of 3 percent to 10 percent of acidless tallow or similar animal fats are desirable. For hypoid gears, an acceptable grade of extreme pressure lubricant is recommended. For applications where loads, speeds or temperatures are abnormal, it may be necessary to use oils with special additives.

SECTION VI—VISCOSITY

The viscosity range for the various AGMA lubricants is shown in Table I. The oils specified by number for the various types of gearing and ambient temperatures must be within this viscosity range.

Table I—Viscosity Range For Various AGMA Lubricants

AGMA Lubricant No.	Viscosity Range S.U.V. Seconds	
	At 100 deg. F.	At 210 deg. F.
1	180 to 240	———
2	280 to 360	———
3	490 to 700	———
4	700 to 1,000	———
5	———	80 to 105
6	———	105 to 125
7	———	125 to 150
7 Comp.*	———	125 to 150
8	———	150 to 190
8 Comp.*	———	150 to 190
9	———	350 to 550
10	———	900 to 1,200
11	———	1,800 to 2,500

*The oils marked "Comp." are those compounded with 3 to 10 percent of acidless tallow or other suitable animal fat.

Oils No. 9, 10 and 11 should be of a tacky adhesive nature so that they will adhere well to the tooth surfaces.

Part II—Oil Lubrication Of Enclosed Gear Units

SECTION I—SCOPE

The recommendations which follow cover the lubrication of enclosed gear units of all types within the range of sizes of commercial enclosed gear drives.

SECTION II—LIMITATIONS

1. The recommendations which follow are applicable to enclosed gear drives in which the high-speed shaft rotates within a nominal speed range of 600 to 1,800 r.p.m. One exception to this is high-speed gear units which normally oper-

ate at speeds higher than 1,800 r.p.m. The recommendations for these are shown in Table II.

2. For spur, helical and herringbone gearing, the recommendations as shown apply only to gears cut after heat-treatment. If they are heat-treated after cutting, the next higher AGMA lubricant number is to be used for a given unit size and ambient temperature.

3. The recommendations as shown for units using straight or spiral bevel gears are for gears heat-treated either before or after cutting.

SECTION III—LUBRICATION RECOMMENDATIONS

1. Table II shows the grade of oil to use for drives of all types except those employing worm gears, and this latter group is covered by Table III.

2. When operating in the 0 to 40 deg. range of ambient temperature, the lubricant selected must have a pour point below the lowest temperature expected.

Table II—Recommended Lubricants for Enclosed Units of All Types Except Worm Gears

Type of Units	Size of Units	Ambient Temperature, deg. F. 0–40 use AGMA No.	41–100 use AGMA No.	101–150 use AGMA No.
Parallel shaft units	Low-speed, Centers up to 20 in.	2	4	5
	Low-speed, Centers over 20 in.	3	5	6
Planetary gear units	O.D. of housing up to 16 in.	2	3	4
	O.D. of housing over 16 in.	3	4	5
Gearmotors	All sizes	2	4	5
Spiral or straight bevel gear units	Cone distance up to 12 in.	2	4	5
	Cone distance over 12 in.	3	5	6
High-speed units	All sizes	1	2	3

Table III—Recommended Lubricants for Enclosed Worm Gear Units Only

Service and Worm Speed	Ambient Temperature, deg. F. 0–40 use AGMA No.	41–90 use AGMA No.	91–120 use AGMA No.
Intermittent operation *All worm speeds	5	5	7 Comp.
Continuous Operation. Worm speeds below 600 r.p.m.	7 Comp. **Diluted	8 Comp.	8 Comp.
Continuous Operation. Worm speeds 600 r.p.m. and over	7 Comp. **Diluted	7 Comp.	8 Comp.

*Where period of operation is insufficient to produce any appreciable rise in oil bath temperature.

**Diluted AGMA No. 7 comp. oil should be diluted with a lighter oil, preferably not exceeding 500 sec. viscosity at 100 deg. F., until the desired fluidity is obtained. The lubricant used for dilution should be of the same basic crude as that of the recommended oil. The lubricant supplier should be consulted if there is any doubt.

SECTION IV—MAINTENANCE

1. To obtain long life from a gear unit, it is necessary that the oil be clean and free from sludge at all times. To be assured of this, the oil must be changed at regular intervals.

2. For a new unit the oil should be drained at the end of two weeks operation and the case thoroughly flushed with light flushing oil. For refilling, the original oil can be used if it has been filtered, otherwise new oil must be used. After this, a change of oil every 2,500 hr. of operation or every six months, whichever occurs first, is sufficient for units operating under normal conditions. Where operating conditions are severe, such as a rapid rise and fall in temperature of the gear case with accompanied sweating of the inside walls and resulting formation of sludge, or where operation is in moist or dusty atmospheres or in the presence of chemical fumes, it may be necessary to change the oil at intervals of one to three months .

3. Sludge in gear units may be caused by metallic particles ground off the gears, from dust and dirt and by the presence of moisture or chemical fumes. Therefore, every precaution should be taken to prevent water and foreign particles from entering the gear case.

Part III—Oil Lubrication of Open Gears

SECTION I—SCOPE

The recommendations which follow cover the lubrication of open and semi-enclosed gearing of all types.

SECTION II—LIMITATIONS

These recommendations are applicable to gears operating at moderate and slow speeds. The maximum permissible speed is that at which the lubricant will adhere to the teeth and will vary with the application and operating conditions.

This part covers oil lubrication of gears as distinguished from grease lubrication. The oil used may, however, contain special additives to increase its adhesiveness.

SECTION III—METHODS OF LUBRICATION

Various methods have been devised for the lubrication of open gearing because of the wide range of applications in which they are used. These methods can, however, be grouped in two general classes which are as follows:

(A) SLUSH-PAN LUBRICATION

This method of lubrication is recommended for high grade heavily loaded gears operating at moderate and slow speeds. It involves the use of a slush pan mounted below one of the gear elements in a position such that a number of gear teeth are submerged in oil. As the gear rotates a small amount of lubricant clings to the teeth and is carried into the mesh.

The oil used should be of a tacky nature so that it adheres well to the tooth surfaces. It should be heavy-bodied but not so heavy as to channel in the pan.

(B) HAND LUBRICATION

Hot—by brush or pouring.

On applications where a slush pan is impractical, this method of lubrication is recommended for moderate speeds and heavy loads or when gears are operating at elevated temperatures. It consists of heating the lubricant to a temperature such that it flows freely and is then applied to the gears with

a brush or by pouring. An extremely adhesive lubricant should be used.

Cold—by brush or pouring.

This method of lubrication is recommended only for slowly moving and roughly cut or cast teeth carrying comparatively light loads. It consists of applying the lubricant to the gears with either a brush or paddle. The oil used should be adhesive in nature so it will stay on the teeth.

Hand-Oiled.

This type of lubrication is limited to small gears which are used principally for motion transmission where the loads are very light. The oil is applied by merely pouring on the gear teeth.

SECTION IV—LUBRICATION RECOMMENDATIONS

Table IV shows the proper AGMA number to use for open gearing of all types except worm gears. Table V covers the recommendations for worm gears only.

Table IV—Recommended Lubricants for Open Gearing of All Types Except Worm Gears

Method	Ambient Temperature, deg. F.		
	0–40 use AGMA No.	41–100 use AGMA No.	101–150 use AGMA No.
Slush Pans	3	5	6
Hot — by brush or paddle	10	10	11
Cold—by brush or paddle	6	8	10
Hand-oiled	4	6	8

Table V—Recommended Lubricants For Open Worm Gears Only

Method	Ambient Temperature, deg. F.		
	0–40 use AGMA No.	41–100 use AGMA No.	101–150 use AGMA No.
Cold or hot— by brush or paddle	6	8	—

SECTION V—MAINTENANCE

1. Because open gearing comprises so many types and is used under such a wide range of operating conditions, it is difficult to make recommendations applicable to all situations. Often such gears are protected by dust-excluding sheet metal housings while others have no covering.

2. For slush-pan lubrication, the oil should be changed once every six months for applications where it is not subject to dust or contamination. Where dust or an excessive amount of moisture is present, the oil should be changed every two to four months.

3. All hand-lubricated gearing depends on the periodic application of oil to the gears to maintain a constant film. The frequency of application depends on speed, load, and operating condition and may vary from one hour where speeds and loads are high to 24 hours for lightly loaded slow-speed drives. The proper intervals between applications can be determined only by inspection of the tooth surfaces.

4. Gears operating in dusty atmospheres should be periodically cleaned with kerosene or other suitable solvent. The dirt and grit adhering to them can seriously damage the tooth surfaces if it continuously passes through the mesh.

Comments and criticisms of this standard will be appreciated. They should be addressed to N. C. Goin, executive secretary, American Gear Manufacturers Association, Empire Building, Pittsburgh 22, Pa.

New Insulations Permit Increased Motor Ratings

WHERE ELECTRICAL DESIGN LIMITATIONS are based on insulation temperature, as much as 50 percent reduction in weight of equipment is possible by use of new Silicone insulating varnishes. Such high-temperature insulation can also allow increased output of small motors, in cases where the same frame can be used and the operating temperature raised. Additional advantages are ability to operate at higher ambient temperature, and longer life when operated at conventional temperature conditions.

Silicone materials bridge the gap between conventional organic insulating materials, which are limited with respect to heat stability, and ceramic type materials, which are not limited with respect to heat stability. Physically, they are quite similar to conventional resins, varnishes, and organic structures, but differ in that they do not readily decompose at temperatures of the order of 200 deg. In actual use, the conventional insulating structures have been modified to incorporate Silicone resins throughout.

According to R. C. Bergvall of the Westinghouse Electric & Manufacturing Company, a 3 hp. totally-inclosed induction motor was so redesigned for 10 hp. with no increase in weight or size. Since then, more than 30 similar motors using high temperature insulation have been built and are now being tested under various conditions. A mine locomotive motor armature has been functioning under adverse conditions for over a year since being rewound and high temperature-insulated. Prior to this, insulation failures occurred frequently, a few less than a month apart. Street car and trolley coach motors with Silicone insulation have been given exhaustive tests at elevated temperatures. Results show increased horsepower output at no increase in speed with no injury to insulation. A 250 kva. generator with high-temperature insulation was operated in the laboratory for about 3,000 hr. at 250 deg. with no ill effects to the insulation. According to the best available means for interpreting accelerated life tests, this should be equivalent to far more then normal life expectancy.

High temperature insulation on several hundred operating coils for magnetic contactors overcame a serious burn-out problem resulting from excessive temperature within the control box. Silicone insulated coils operated for more than a year without a single failure as contrasted to coils with conventional insulation failing within a year. Air cooled transformer life has been increased and output improved when insulated with high temperature materials. Hundreds are in service.

Where temperature, or size and weight as determined by temperature, are important factors in electrical equipment design, the problem should be examined in the light of these recently developed insulating materials.

Thermal Properties of Plastics Determine Limits of Application

W. S. LARSON
Plastics Department, General Electric Company

Heat resistance, thermal conductivity, thermal expansion and shrinkage, and specific heat are discussed from the standpoint of their importance in design of plastic parts. Optical properties of plastic materials are also covered because optical applications depend on temperature qualities.

THE true thermal properties of a material are thermal expansion, thermal conductivity, specific heat and thermal emissivity. In addition, the softening and distortion points of the material are considered as associated properties. Although these points represent merely the effect of temperature on such properties as flexural strength and modulus of elasticity, they indicate the basic differences between thermoplastic and thermosetting resinous materials.

The sensitivity of electrical and mechanical properties of plastics to relatively slight changes in temperature has been indicated in previous articles of this series. (PRODUCT ENGINEERING, May, pages 329–332 and July, pages 469–472.) This consideration probably is the greatest single factor in determining the suitability or unsuitability of a material for a specific application. Invariably, the part designer's first question is, "What is the operating temperature?"

Table I—Heat Distortion, Softening and Maximum Continuous Safe Operating Temperatures of Plastic Materials

Material	Heat Distortion, deg. F.	Softening Point, deg. F.	Maximum Safe Continuous Operating Temperature, deg. F.
Phenolic, wood-flour filled	240	none	250
Phenolic, fabric filled	240	none	250
Phenolic, asbestos filled	290	none	300
Urea	260	none	170
Melamine, asbestos filled	270	none	300
Cast phenolic		180–212	160
Cold-Molded, non-refractory		none	500
Cold-Molded, refractory		none	1,300
Mycalex		1,100	600
Cellulose Acetate, medium flow*	160	195	160
Methyl Methacrylate	160	230	180
Polystyrene	175		180

* Values for soft and hard flows are approximately ± 25 percent of the values shown.

Heat Resistance

In defining heat resistance, it is necessary to appreciate that different users of plastics have different definitions tailored to their individual requirements. The fabricator who forms thermoplastic sheets by drawing does so by heating them to their "softening point." The designer who is working on a mounting base for control apparatus is interested in the "maximum safe continuous operating temperature" for that plastic part. If the part is merely a spacer or cover, the maximum safe continuous operating temperature would obviously be higher than if the part were to be subject to stress and distortion. Hence, "maximum safe continuous operating temperature" is an arbitrary value for a given material used on a given product. It is generally understood to be that temperature at which the material will not become blistered or distorted or sustain an appreciable loss in appearance or mechanical strength.

Aside from these functional tests, a standard measure for heat distortion is needed to evaluate and compare materials. The A.S.T.M. Test D648 fulfills this need by measuring the amount of deflection of a simple beam under a prescribed load. The temperature at which the beam deflects 10 mils is known as the heat distortion point. This temperature has no significance other than this distortion point, and it may or may not be higher than the maximum safe continuous operating temperature.

Thermoplastic materials unfortunately become easily distorted just at temperatures that are inconveniently critical. These are the temperature of boiling water, the temperature at which much industrial apparatus operates and the temperature to which outdoor applications are frequently subjected. In these types of applications, thermoplastics must be used with caution. Much research is being done on the development of thermoplastic materials that will have operating temperatures just above these critical limits, and achievement of this goal can be considered inevitable.

Thermosetting materials readily withstand these temperatures, but have similar limits which in turn must not be exceeded. The phenolics, ureas and melamines usually do not fail by softening or distortion in service, because of their rigid three-dimensional cross-linked structure, but rather by loss of mechanical strength or appearance caused by overheating of the filler material or the resin itself. Phenolics are greatly influenced by filler material. Compounds with cellulose-base fillers such as wood flour, cotton flock and rag fiber are seriously weakened in impact and flexural strength after long exposure to temperatures over 270 deg. F. Asbestos-filled phenolics are notable for heat resistance and can be considered safe up to 420 deg. F.

Cold-molded plastics are outstanding

in their resistance to extended heating. These materials have binders that are not truly resinous and may be completely inorganic. They are usually divided into refractory and non-refractory materials. The former is generally made from clay or Portland cement with an asbestos filler. A refractory cold-molded plastic can withstand temperatures up to 1,300 deg. F. The non-refractory materials are generally mixtures of asphalt, pitch and oil with an asbestos filler. They are frequently thermosetting, but a few are thermoplastic in nature. These materials are used for connector plugs for electric irons, handles on cooking ware, sockets for high-temperature lamps and similar applications.

Thermal Conductivity

The coefficient of thermal conductivity is an expression of the ability of a material to conduct heat. It must be investigated in design work when:

1. An insulating material for refrigerators, wall panels or table mats is needed.

2. A material is desired that will be comfortable to the touch in cold weather.

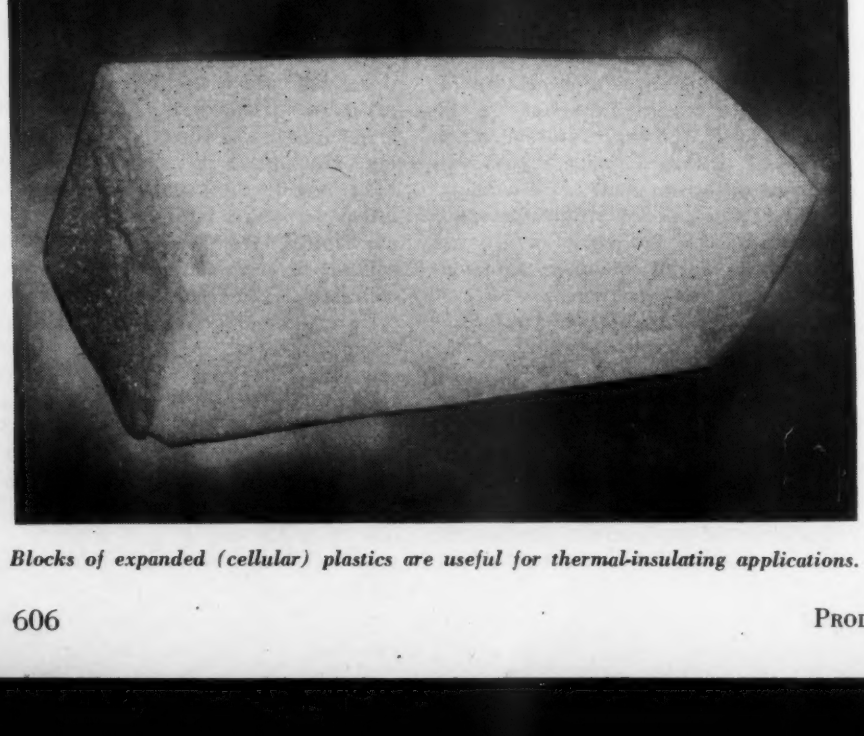
3. A cover or base for a heat-generating assembly must dissipate the heat at a minimum rate.

The plastics of particular interest here are the expanded materials, such as the foam materials of phenolic, ureas, rubber, polyvinyl formal, polystyrene and cellulose acetate. They have a cellular structure which makes them good thermal insulators with excellent possibilities.

All plastic materials can be considered as comfortable to the touch when cold, at least in comparison to the metals. This is because of the low thermal conductivity of the material which makes it impossible to conduct heat away from the hand rapidly enough to be uncomfortable. When a plastic is called upon to dissipate heat, the asbestos filled phenolics are doubly valuable because of their high operating temperature and their relatively high thermal conductivity.

Table II—Thermal Properties of Various Materials Commonly Used for Temperature Applications

Material	Thermal Conductivity, cal./sec./cm.²/deg. C./cm.	Thermal Expansion, in./in./deg. C.	Specific Heat, cal./gm./deg. C
Phenolic, wood-flour filled	0.00060	0.000030	0.35
Phenolic, fabric filled	0.00050	0.000025	0.35
Phenolic, asbestos filled	0.00120	0.000015	0.28
Urea	0.00070	0.000025	0.40
Melamine, asbestos filled		0.000030	
Cast Phenolic	0.00040	0.000028	0.35
Phenolic Foam	0.00013		
Cold-Molded, non-refractory	0.00170		
Vinyl Chloride			
Vinyl Copolymer, chloride-acetate	0.00040	0.000070	0.24
Methyl Methacrylate	0.00060	0.000080	0.40
Polystyrene	0.00020	0.000070	0.32
Cellulose Acetate	0.00060	0.000150	0.40
Ethyl Cellulose	0.00050	0.000120	0.40
Nylon	0.00060	0.000100	0.55
Saran	0.00022	0.000160	0.32
Expanded Rubber	0.00008		
Hair Felt	0.00010		
Steel	0.17000	0.000012	0.10
Aluminum	0.50000	0.000024	0.20
Brass		0.000019	0.09



Blocks of expanded (cellular) plastics are useful for thermal-insulating applications.

Thermal Expansion

The thermal expansion of plastics is from 2 to 8 times greater than that of brass and aluminum, and up to 15 times greater than that of steel. Thus, plastic-metal assemblies that are molded or rigidly fastened together present a problem in unequal expansion. When the temperature rises, the plastic may distort, crack or buckle. The stiffer and harder the material is, the less it tends to accommodate the distortion and the more apt it is to crack. This is especially true where the metal is molded in as an integral part of the plastic.

Plastic parts are frequently proof tested for material and for design by chilling them to —70 deg. C. for 1 hr., warming them to room temperature for 1 hr., and then heating to 120 deg. C. for 1 hr. This cycle will cause failure if the part is poorly designed or molded, or if the application of the material is wrong.

Another consideration is the effect of thermal expansion of plastic parts which have been molded or machined to close tolerances. Parts which must operate within outdoor limits of —40 deg. F. and 160 deg. F. will change 4 mils per inch or more if they are wood-flour-filled phenolic and 15 mils per inch if they are cellulose acetate. This dimensional change or unequal expansion between component parts can cause binding and misalignment and seriously affect the performance of the assembly. Molded rotors for airplane magnetos may change diameter as much as 0.010 in. in the range of their service temperature. Experience has shown that these parts can be thrown out of

tolerance by the difference in temperature between morning and afternoon in the shop in which they are machined.

The range of values for the coefficient of thermal expansion is caused partially by the change in value at different temperatures. Methacrylate, for instance, has a coefficient of 0.00006 in. per in. per deg. C. at −75 deg. C. and a coefficient of 0.00011 in. per in. per deg. C. at 75 deg. C. Melamine compounds will expand 0.000018 in. per in. per deg. C. at −45 deg. C. and 0.00004 in. per in. per deg. C. at 75 deg. C., to cite another example.

The specific heat of plastic materials is one of the lesser-used physical properties. Values are available, however, for the calculation of heat exchanges and heat absorption, and are listed in Table II. Emissivity is concerned primarily with the radiance of heat from a body held at a high temperature, and is not a value of interest for plastics.

Optical Properties

Problems involving the application of transparent plastics are closely associated with heat resistance. This is because there is, as yet, no clear transparent plastic commercially available that will reliably withstand temperatures over 100 deg. C. The thermosetting resins, with the exception of the cast polymerizing resins, are not available in clear transparent. Unfilled phenolic can be molded in amber and in darker colors which withstand temperatures of 121 deg. C. This material is used for such applications as colored signal caps on industrial control apparatus and dairy equipment which must undergo sterilization in boiling water.

All of the more common thermoplastic materials are available in clear transparent and in all colors and degrees of transparency, depending upon the dyes and pigments added. Several of the materials, however, are outstanding for their superior optical qualities and their resistance to deterioration. Transparency of clear materials is commonly evaluated by the percent of light transmitted and by the haze value, which is the percent of light diffused. Thus, a perfectly transparent material would have a light transmission of 100 percent and a haze value of 0 percent.

Before specifying a transparent material, the designer should anticipate those conditions which will affect it adversely. Chief among these are the effect of sunlight and weathering, chemicals and chemical fumes, abrasives, and mechanical stresses and deformations. These conditions induce waviness, distortion, discoloration, scratches and crazing, in which tiny internal cracks appear in the material. Applications that are subject to mechanical stresses or solvents and solvent vapors are especially susceptible to crazing.

A number of plastic materials compare favorably with glass with respect to light transmission. Advantages of plastics over glass are moldability, machinability and resistance to shock and shattering. Chief disadvantages are low abrasion resistance and low maximum safe operating temperature.

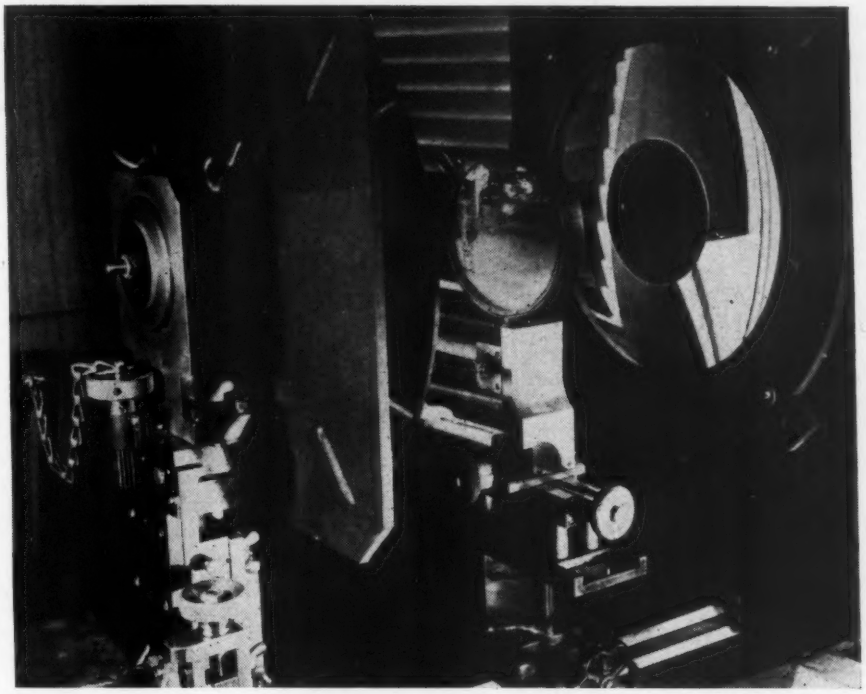
Translucense is a degree of transparency in which the light transmission is low (that is, 50 percent for a $\frac{1}{16}$-in. thick urea laminate) and the haze value, or the diffused light, is nearly 100 percent. The most widely used application for translucent plastics is molded and laminated urea in lighting fixtures. Here again heat resistance is one of the limiting factors in design. The maximum safe continuous operating temperature is far below the heat distortion point because the material will discolor at temperatures above 74 deg. C. This is the temperature 3.5 in. from the filament of a 200-watt bulb or 6 in. from a 500-watt bulb.

The index of refraction of transparent plastics is slightly lower than that of glass. These materials are widely used, however, for the production of molded lenses of considerable accuracy.

Eyeglasses of the contact type are molded in this manner and recent developments have shown that large corrective lenses of unusual shape for television optical systems can be molded. Another application based on the refractive index and the critical angle of total reflection is the use of transparent plastics to "pipe" light. Under certain conditions light can be transmitted internally through the material from a source to a desired outlet. By proper design, the light can be directed out of the end of a transparent rod or used to illuminate letters or figures that have been etched into transparent sheets.

Table III—Principal Optical Properties of Clear Plastics

Material	Light Transmission		Haze Value	
	new	aged 1 yr.	new	aged 1 yr.
Methyl Methacrylate	94	93	2	3
Cellulose Acetate	91	91	5	8–28
Cellulose Acetate Butyrate	89	89	8	8
Vinyl Chloride-Acetate	83	83	7	7
Cellulose Nitrate	88	38	5	97
Vinyl Butyral	71	10	5	99
Ethyl Cellulose	89	very low	5–12	very high



Aspherical lens, accurately molded from methyl methacrylate, is the heart of a television unit that will project bright and clear images up to 15x20 ft. in size.

Design Data for Spot Welds In Aluminum Alloy Sheets

JAMES RALSTON
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Welding principles and basic considerations that govern the design of spot welded parts made of aluminum alloy sheets are enumerated, with data pertaining to weldability of different aluminum alloys, mechanical properties of spot welded joints, gage combinations, spot spacing, edge distances and surface preparation.

RESISTANCE welding, in general, is based on the physical fact that resistance is offered by a metal to the passage of an electric current. If sufficient current is applied the resistance offered results in sufficient heat to cause fusion of metals. Hence, the greater the resistance to flow offered by a metal the greater is the heat resulting from the passage of current through the metal.

Since the heating effect of any given current value is increased with the resistance of the metal to be welded, it follows that high resistance metals such as stainless steel, cold-rolled steel, some bronzes and similar metals weld with low current values. Aluminum alloys, magnesium alloys, high copper alloys are low resistance metals and weld only with high current values.

Pressure is also required, in making sound spot welds, to hold the metal parts together during the application of the current. Also after the current is applied, pressure is needed to forge the heated areas of the joining sheets. It is necessary that pressure be varied with each combination of metals so that correct pressure can be applied with the welding current. Excessive pressure will overforge the weld, will distort the sheet and will mushroom the electrodes. Insufficient pressure will cause a bad contact which will result in poor fusion, excessive flash, or may burn holes in the metal.

A spot welding machine consists primarily of welder arms made of copper rods of large diameter to carry the high amperage load, water-cooled electrodes clamped or otherwise held into the work end of the welder arms, a transformer to reduce the incoming voltage and to increase the current passing between the electrodes, and an operating switch to turn the current on and off to the transformer. The switch can be manually or foot operated, or operated at regulated intervals by an automatic cam.

Spot welds should be free of cracks, blow holes, and porosity. If a satisfactory weld does not result it may be caused by any of a number of variables such as unclean surface of part or electrode tip, incorrect setting of welding

Table I—Weldability of Aluminum Alloy Combinations

Alloy	24S–T Alclad 24S–RT Alclad	17S–T Alclad 17S–RT Alclad	3S–H 3S–1/2H	52S–H 52S–1/2H	17S–T 24S–T Extr.	53S–W 53S–T	17S–O Alclad 24S–O A1	2S–O, 3S–0 2S–1/2H 52S–O 2S–H, 53S–0
24S–T Alclad.... 24S–RT Alclad..	A	A	B	B	A	A	C	C
17S–O Alclad.... 24S–O Alclad....	C	C	B	B	B	B	A	B
17S–T Alclad.... 17S–RT Alclad..	A	A	B	B	A	A	C	C
24S–T..... 24S–T Extrusion.	A	A	B	B	A	A	B	C
3S–H..... 3S–1/2H.....	B	B	A	A	B	B	B	B
52S–H..... 52S–1/2H.....	B	B	A	A	B	B	B	B
53S–W..... 53S–T.....	A	A	B	B	A	A	B	B

A = Excellent, B = Fair, C = Not Recommended.

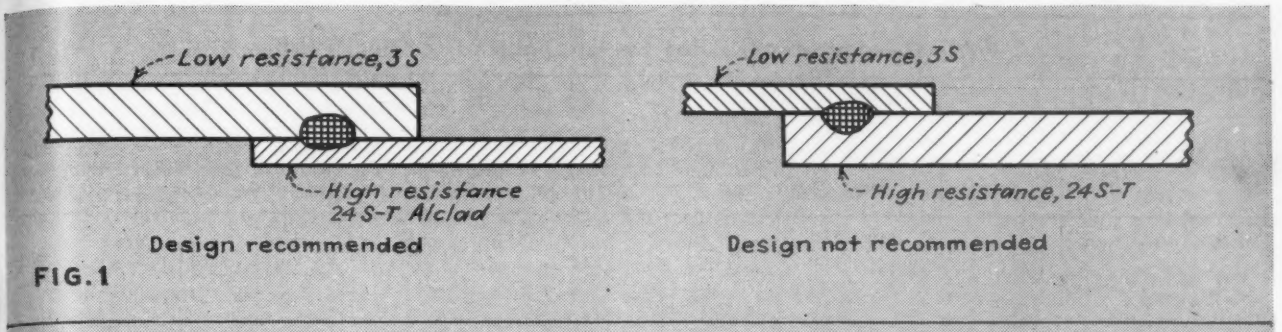


FIG. 1

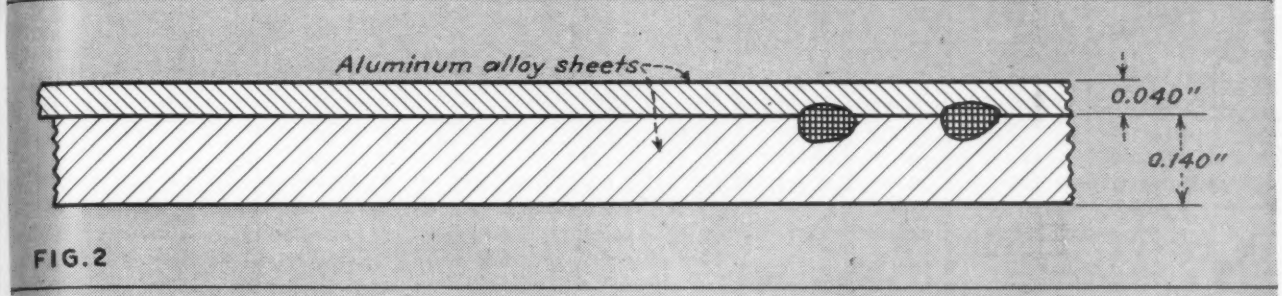


FIG. 2

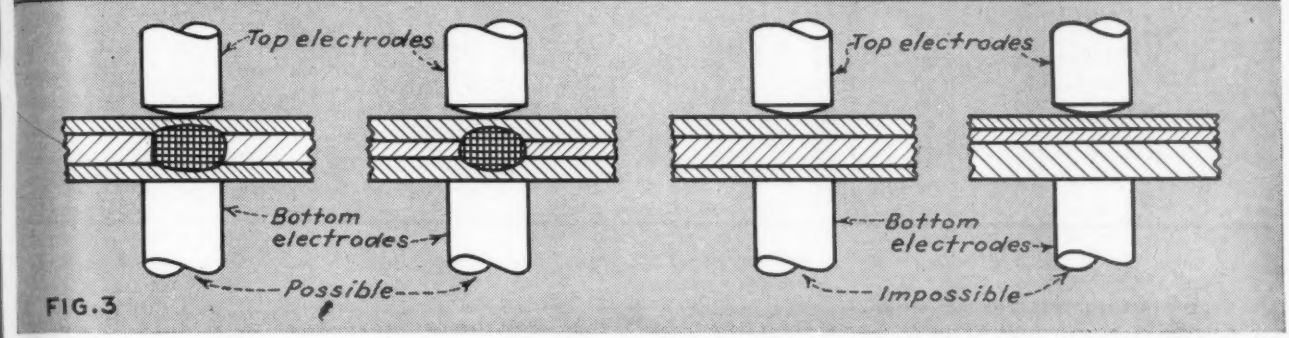


FIG. 3

Fig. 1—When designing a spot welded joint in two aluminum alloy sheets of different resistance values, it is recommended that the sheet with the lowest resistance value be the thick sheet and the top one in the joint. Fig. 2—In spot welding two aluminum alloy sheets of different thicknesses, about 3½ to 1 is the maximum allowable thickness ratio. Fig. 3—In spot welding three or more aluminum alloy sheets, about 3 to 1 is the maximum allowable ratio between any two thicknesses.

current or time, improper pressure at welding tips, and incorrect pressure time.

Since the soundness of a spot weld is often not visually apparent on the surface, the welds should be periodically checked by testing samples for shear strength and by examination under the microscope. Tests of this kind check both the consistency of the operator and the operation of the welding machine.

The productivity of spot welding is not only governed by the operator and the spot welding machine but also by the designer of the parts to be joined. The designer by increasing the length of run between starting and stopping the machine, making assemblies accessible, carefully considering the ratio of thickness of the materials to be welded, and allowing proper edge distances can do much to increase the efficiency and productivity of the spot welder and his equipment.

Welding characteristics of the various aluminum alloys vary considerably, although in general all the alloys can be spot welded. Table I gives the weldability of different combinations of aluminum alloys.

In the aluminum alloys, those in the high tensile group such as 17S-T and 24S-T are easier to weld as they have less tendency for sheet separation and in general better weld strength consistency. On the other hand, they have a tendency toward cracks and porosity.

The low strength alloys such as 3S and 52S result in more sheet separation, lower weld strength, less consistency and greater indentation, but are generally free from cracks and porosity.

Shrinkage cracks are more prevalent in copper bearing alloys such as 17S and 24S. Chromium bearing alloys like 61S, 52S and 53S have a greater tendency towards porosity and cavities, particularly when hardened.

In joining dissimilar alloys, it should be remembered that alloys possessing more nearly similar electrical resistance and meeting points are easiest to join, and conversely alloys with greatest difference in resistivity and melting points are more difficult to join.

A spot weld develops its fullest strength when subjected to shear loads. Minimum allowable shear loads which a good spot weld may carry are given in Table II. The strongest individual spot weld does not necessarily produce the strongest joint, it is a combination of spot welds in a definite pattern or design that gives the desired results.

Spot welding should never be used on an assembly where any appreciable tension load will be applied to the spot welds. The tensile strength of a spot weld is only about 25 percent of its shear strength.

When two or more different alloys, or combinations of unequal thickness are spot welded, the design value should be based on the lower strength alloy or the thinner sheet.

When joining two parts which have been stressed so that the joints are in tension and individual spot welds are in shear, the objective is usually to secure a joint the ultimate strength of which is equal to the parent metal. Because the change from a heat-treated wrought structure to an annealed cast structure, the spot welds on most aluminum alloys

Table II—Aluminum Alloy Design Values for Spot Welding

Alloys	Gage, In.	Spot Spacing, In. Min.	Nominal	Max.	American Welding Standards: Min. Edge Dist., In.	Min. Allow. Spot Shear, Lb.	Max. Allow. Spot Shear, Lb.	Army: Min. Allow. Spot Shear, Lb.	Navy: Min. Allow. Spot Shear, Lb.
	0.016	0.38	0.50	0.75	3/16	140	265	110	140
17S–T Alclad.....	0.020	0.38	0.50	0.75	3/16	180	350	140	180
24S–T Alclad.....	0.025	0.38	0.50	0.75	7/32	235	445	180	230
17S–RT Alclad...	0.032	0.50	0.62	1.00	1/4	310	555	250	290
24S–RT Alclad...	0.040	0.50	0.62	1.25	1/4	430	775	345	370
17S–T.....	0.051	0.62	0.75	1.50	5/16	575	1,040	480	570
24S–T.....	0.064	0.62	0.75	1.75	3/8	880	1,525	700	800
24S–RT.....	0.072	0.75	1.00	2.00	3/8	1,025	1,715	820	1,000
17S–RT.....	0.080	0.75	1.00	2.00	3/8	1,275	2,000	1,025	1,150
	0.091	0.75	1.00	2.25	7/16	1,520	2,250	1,275	1,400
	0.102	1.00	1.50	3.50	7/16	1,740	2,460		1,600
	0.114	1.10	2.00	4.00	1/2	1,965	2,680		1,720
	0.125	1.20	2.00	4.00	1/2	2,130	2,850		2,000
52S–W, 52S–T....	0.016	0.380	0.5	0.625	3/16			105	120
53S–W, 52S–T....	0.020	0.380	0.5	0.625	3/16			137	150
61S–W.....	0.025	0.50	0.5	0.625	7/32			180	175
61S–T.....	0.032	0.50	0.75	1.00	1/4			230	300
2S–1/4H.....	0.040	0.625	0.75	1.20	1/4			310	400
2S–1/2H.....	0.051	0.75	0.75	1.30	5/16			735	580
3S–1/4H.....	0.064	0.75	1.00	1.40	3/8			620	800
3S–1/2H.....	0.072	1.00	1.00	1.50	3/8			725	940
	0.080	1.00	1.10	1.50	3/8			852	1,100
	0.091	1.10	1.25	1.75	7/16			1,100	1,280
	0.102	1.10	1.35	1.75	7/16				1,470
	0.114	1.20	1.50	2.00	1/2				1,720
	0.125	1.20	1.50	2.00	1/2				2,000

are weak when compared to the parent metal. Where maximum strength is needed in a lap joint, two or more rows of spot welds should be used.

Gage combinations, as well as materials, play an important part in the weldability of a joint. In general, it is more feasible to join a high resistance alloy that is thin in gage with a low resistance alloy that is thick in gage than it is to fuse a thick section to a thin section of the same alloy.

Any two aluminum alloy sheets of the same or different alloy and of the same or different thickness can be spot welded together with no great difficulty if the thickness of the thinner sheet is not more than approximately 0.125 in. and the total thickness of the two sheets is not more than 0.250 in. Three or more sheets of the same or different thickness can be spot welded together if the total thickness does not exceed 0.250 inches.

Ratio of Sheet Thicknesses

In any spot welded aluminum joint that is made of two sheets, the ratio of the thicknesses of thick to thin sheets should not be greater than 3½ to 1. When three or more thicknesses are to be spot welded together, the maximum allowable ratio between any two thicknesses is 3 to 1. The limitations given here assume the use of standard welding machines now generally available. When designing a spot welded joint of different sheet thicknesses, the design values of the thinnest material should be used.

The welding pressure that must be exerted by the electrodes to make a good weld is directly proportional to the thickness of the sheet in contact with the upper electrode. This electrode has a spherical end surface which puts a slight dimple in the heavier sheet. The other sheet rests on the bottom stationary electrode which is flat leaving the sheet perfectly smooth. If two spherical electrodes or two flat electrodes are used the pressure is proportional to the thinner of the two sheets. Time and heat remaining the same, the diameter of the spot decreases with increase in welding pressure.

Welding Time

The welding time required for a good weld is proportional to the average thickness of the sheets being welded together. The amperage or heat to make the weld is also increased with increase in sheet thickness. The diameter of the spot for a weld of adequate strength is a function of the thicknesses of the sheets being welded together, increasing as the thickness of the sheet increases. This is an important consideration as the diameter of the spot is the determining factor with reference to the strength of the spot welds and their minimum edge distance, that is, the distance from the center of the spot to edge of sheet.

Since the diameter of the spot weld is determined by the sheet thickness, the edge distance is likewise determined by the thickest sheet in the joint.

Edge distance in spot welding is more important than in riveting. Insufficient edge distance may permit pressure and heat to cause spitting and extruding in a weak weld and reducing operating speed. Spot welds placed too near the edge of a sheet will cause the edge to be pushed outward possibly to the point of cracking. Such a condition might, under vibration or high repeated load, cause a fatigue failure. Excessive edge distance allows gaps to form between faying surfaces.

The minimum spot spacing values given in Table II are the smallest that will allow full spot strength, since closer spacing causes shunting action during welding.

All aluminum and aluminum alloys should be suitably treated prior to spot welding to expedite the welding operation and to improve the weld quality.

Pre-weld surface preparation of aluminum and aluminum alloys has for its objective the elimination of variations in the heat of welding caused by variations in the contact surface resistance of unprepared aluminum sheets, and to reduce to a minimum the heating between the aluminum sheet

and the welding electrodes supplying current to the weld.

Surface resistance of aluminum sheets is caused by the presence on the sheet of foreign substances either deposited on the sheet in the course of handling, or formed chemically by the action of the atmosphere or other agents brought in contact with the sheet during fabrication.

It is important to realize that the mechanical and chemical films constituting the surface resistance are in no way similar, and different methods must be used for the removal of each film.

The surface of aluminum to be spot welded must be clean to prevent heating and burning of the outer surface. The fundamental principle of spot welding is obtaining fusion between inner surfaces of the parts to be joined. In addition, clean surfaces are necessary to prevent surface heating which will result in surface "pick up" of copper from electrode tips. Aluminum will readily absorb copper at elevated temperatures.

It is thus imperative to remove both dirt and the oxide film from the surfaces of the parts welded coming in contact with the welding electrode to insure welds with good surface appearance and to minimize electrode pickup, and thus increase electrode life.

The need for removing the oxide film between the surfaces being welded is equally important though not so apparent as removing mechanically deposited film such as oil and dirt. The chemical film of aluminum oxide present on all aluminum and its alloys is non-uniform in character. In addition, it is frequently of such magnitude that a breakdown through the film requires an appreciable potential with the result that when it does occur the passage of welding current is sharply localized at a few points which in turn results in excessive local heating, expulsion of weld metal from the weld, well cavities, and irregularity in the shape of the welds.

Theoretically the contact resistance between the surfaces welded need not be reduced to zero, but can remain at a certain uniform and preferably fairly low value. In practice, it is difficult to reproduce this condition consistently. The best procedure is to reduce the surface film to as low a value as possible.

Surface Preparation

An ideal surface preparation method would remove all mechanically or chemically deposited film from the surface without attacking the alloy or the aluminum cladding. In addition, the method should leave the surface protected with a uniform chemical film of low resistance, inhibiting the formation of a uniform oxide film which would otherwise form the moment aluminum or its alloys are exposed to the atmosphere. But the resistance of this protective film should not be materially different from that of the alloy. A protective film of this type would permit an indefinite length of time exposure for all gage thicknesses, and would permit welding several days after cleaning.

Mechanically deposited films of dirt or oil can be removed by several means from the surface of aluminum or its alloys. Any oil or grease dissolving operation combined with some form of mechanical agitation such as spraying or wiping action which results in positive removal of oil, grease, and dirt is satisfactory. Vapor degreasers and chemical baths are the most satisfactory. With proper supervision and technique, hand wiping with acetone or other hydro-carbon solvents is also satisfactory.

The removal of foreign substances such as oil or dirt from the aluminum surface is not only necessary in its self, but also to permit the subsequent removal of the oxide film since most of the means capable of attacking the oxide film are rendered ineffective to a large degree by the presence of oil or grease, and will not operate unless the surface is chemically clean.

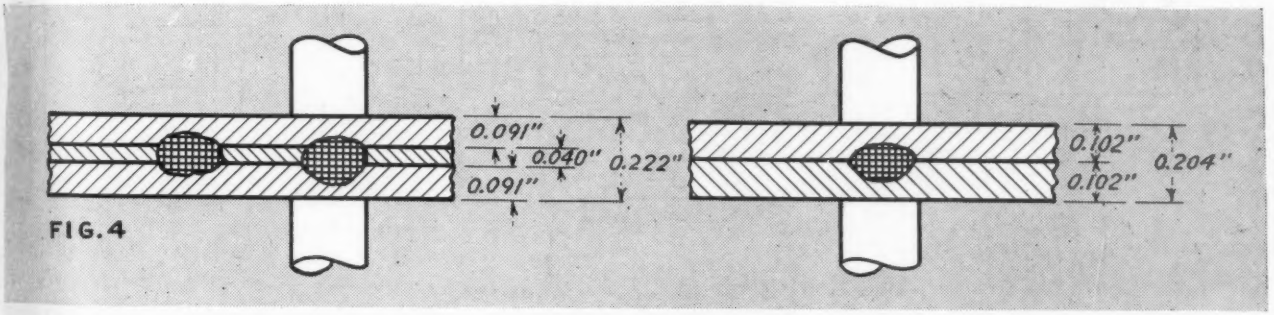


Fig. 4—Types of acceptable spot welded joints if combined thicknesses are not more than allowable total thickness.

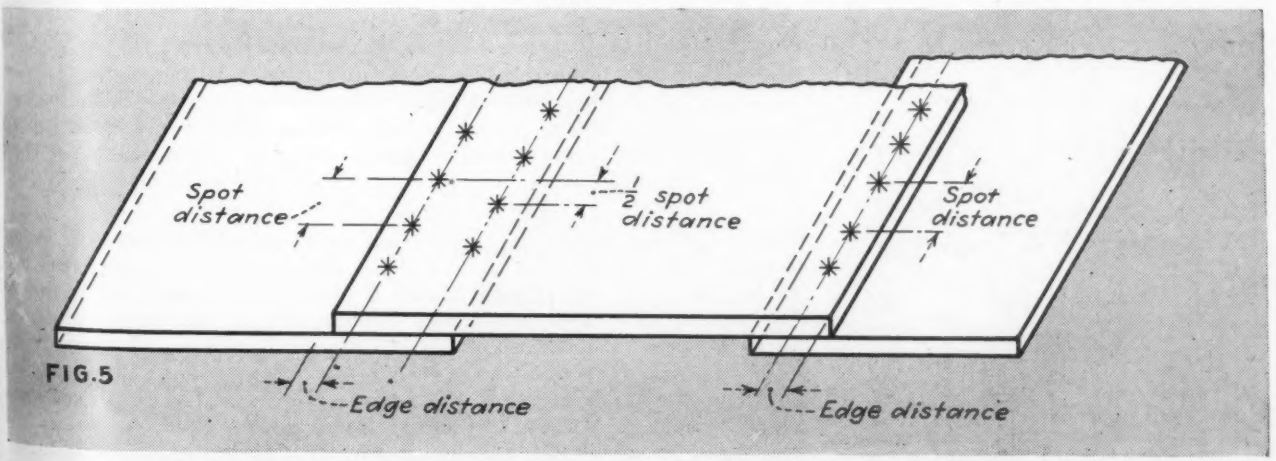
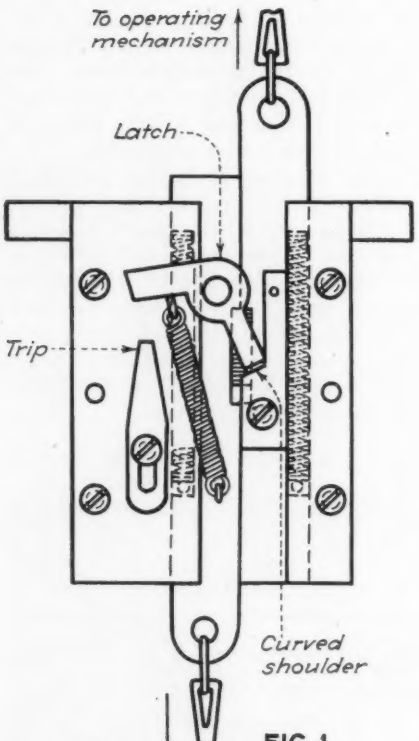
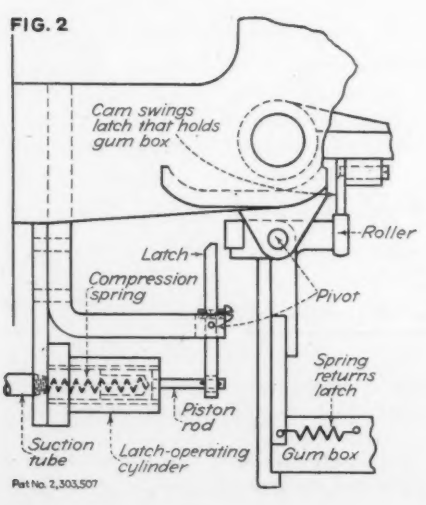


Fig. 5—Single row and staggered double row arrangements of spot welds. Table II gives allowable spot spacing distances for sheets of different gages and materials.

AUTOMATIC STOPPING MECHANISMS

Many machines, particularly automatically operated production machines, may damage themselves or parts being processed unless they are equipped with devices that stop the machine or cause it to skip an operation when something goes wrong. The accompanying patented mechanisms show principles that can be employed to interrupt normal machine operations: Mechanical, electrical or electronic, hydraulic, pneumatic, or combinations of these means. Endless varieties of each method are in use.





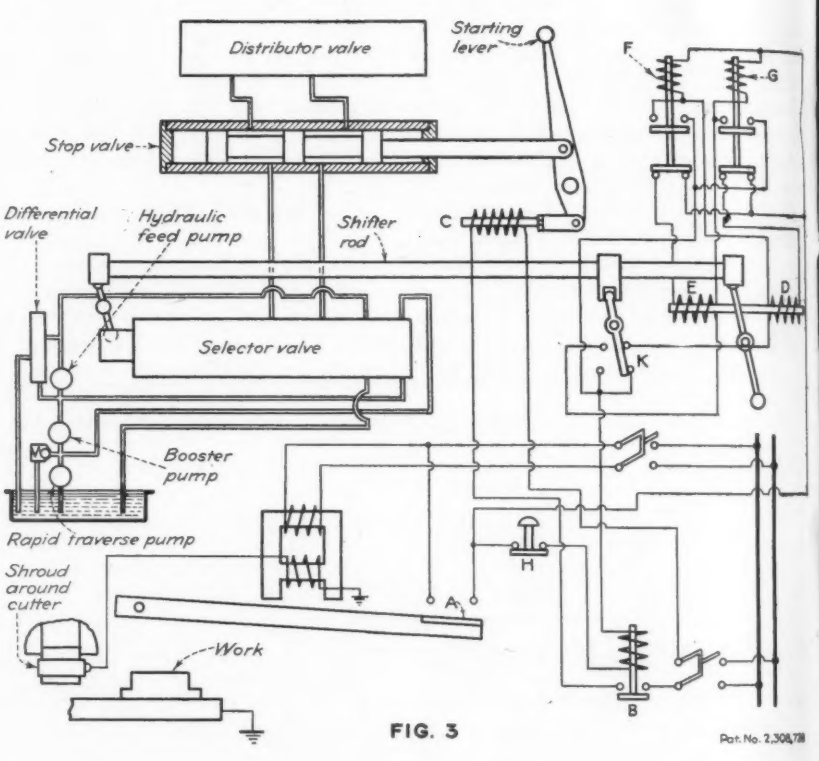


Fig. 1—Repetition of machine cycle is prevented if pedal remains depressed. Latch carried by left slide pushes right slide downward by means of curved shoulder until latch is disengaged by trip member.

Fig. 2—Gumming of suction picker and label carrier when label is not picked up by the suction, is prevented by insufficient suction on latch-operating cylinder, caused by open suction holes on picker. When latch-operating cylinder does not operate, gum box holding latch returns to holding position after cyclic removal by cam and roller, thus preventing gum box and rolls from rocking to make contact with picker face.

Fig. 3—Damage to milling cutter, work or fixtures is prevented by shroud around cutter, which upon contact closes electric circuit through relay, thus closing contact *A*. This causes contact *B* to close, thus energizing relay *C* to operate stop valve, and closes circuit through relay *D*, thus reversing selector valve by means of shifter rod so that bed travel will reverse on starting. Simultaneously, relay *F* opens circuit of relay *E* and closes a holding circuit that was broken by the shifter lever at *K*. Relay *G* also closes a holding circuit and opens circuit through relay *D*. Starting lever, released by push button *H*, releases contact *A* and returns circuit to normal. If contact is made with shroud when bed travel is reversed, interchange *D* and *E*, and *F* and *G* in above sequence of operations.

FOR FAULTY MACHINE OPERATION

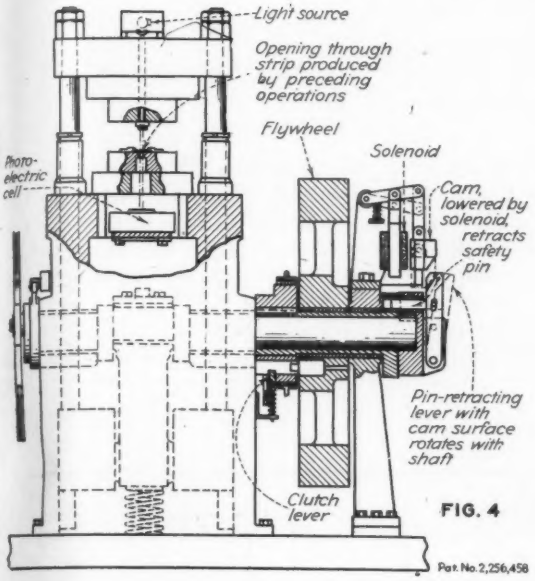


FIG. 4

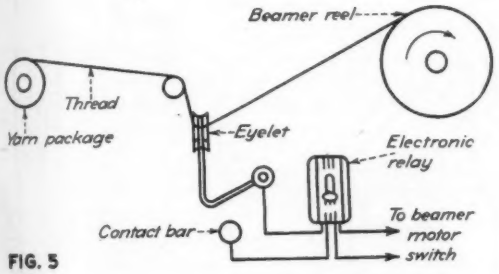


FIG. 5

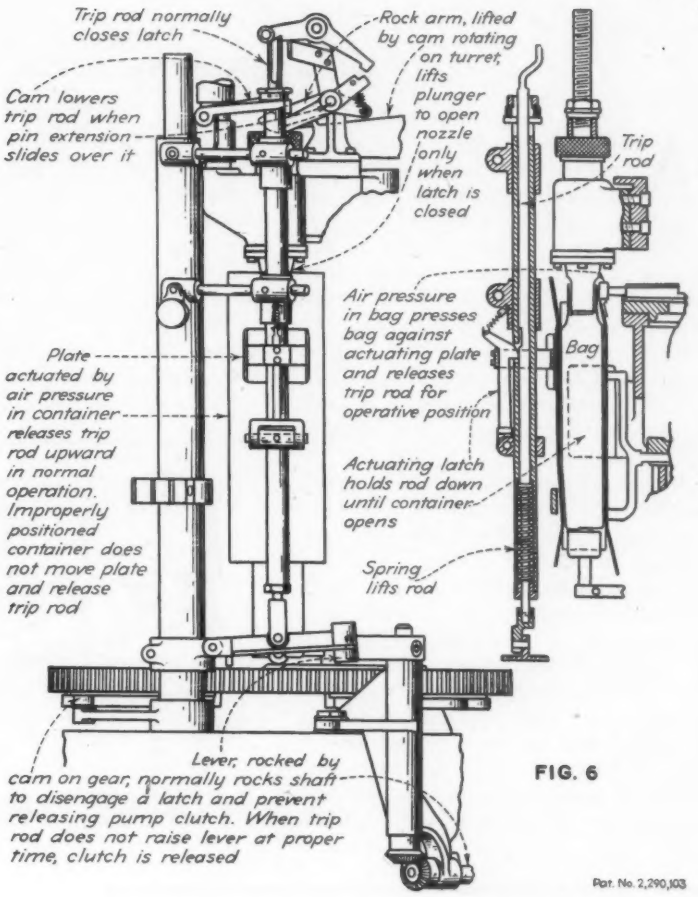

Trip rod normally closes latch
Rock arm, lifted by cam rotating on turret, lifts plunger to open nozzle only when latch is closed
Cam lowers trip rod when pin extension slides over it
Trip rod
Air pressure in bag presses bag against actuating plate and releases trip rod for operative position
Bag
Plate actuated by air pressure in container releases trip rod upward in normal operation. Improperly positioned container does not move plate and release trip rod
Actuating latch holds rod down until container opens
Spring lifts rod
Lever, rocked by cam on gear, normally rocks shaft to disengage a latch and prevent releasing pump clutch. When trip rod does not raise lever at proper time, clutch is released
Pat. No. 2,290,103

FIG. 6

Fig. 4—High-speed press is stopped when metal strip advances improperly so that hole punched in strip fails to match with opening in die block to permit passage of light beam. Intercepted light beam to photo-electric cell results in energizing solenoid and withdrawal of clutch pin.

Fig. 5—Broken thread permits contact bar to drop, thereby closing electronic relay circuit, which operates to stop beamer reeling equipment.

Fig. 6—Nozzle on packaging machine does not open when container is not in proper position.

Fig. 7—Obstruction under explorer foot of wire-stitching machine prevents damage to machine by raising a vertical plunger, which releases a latch lever so that rotary cam raises lever that retains clutch operating plunger.

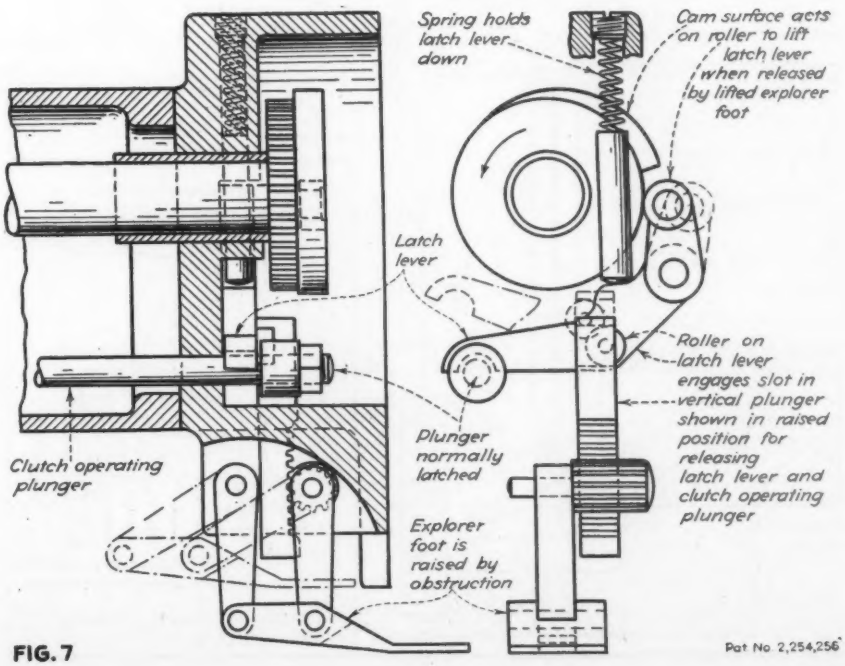

Spring holds latch lever down
Cam surface acts on roller to lift latch lever when released by lifted explorer foot
Latch lever
Roller on latch lever engages slot in vertical plunger shown in raised position for releasing latch lever and clutch operating plunger
Plunger normally latched
Clutch operating plunger
Explorer foot is raised by obstruction
Pat. No. 2,254,256

FIG. 7

Bellows Sealing Device Protects Bearings From Abrasives

ROGER W. BOLZ
Assistant Engineer, Clarksburg Works, National Carbon Company

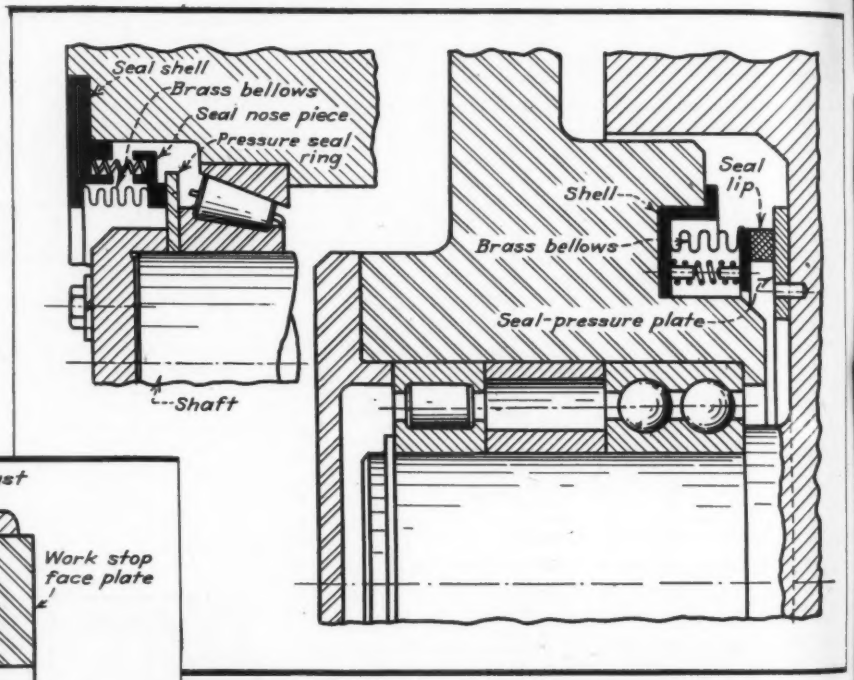
A SPRING-actuated brass bellows which maintains continuous seal contact has been designed for a planetary-type miller to exclude abrasives, dust, water and corrosion when bearings are loose, misaligned or eccentric. The bearing seal was designed for the miller to cope with infiltration of abrasives severe enough to cause rapid destruction of the lubrication system and bearings. The unit is now in its second year of successful operation.

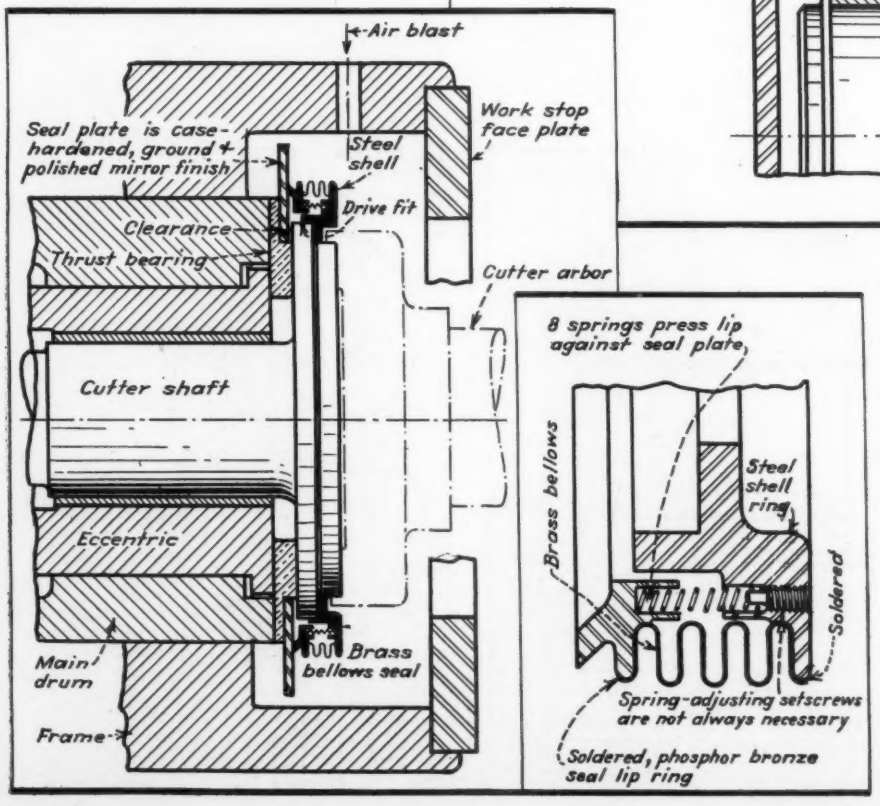
Planetary throw action, which creates an eccentric cutter path during the operating cycle, offered the greatest obstacle to effective sealing. It necessitated efficient sealing as the shaft rotated at constant speed while the eccentric moved from a neutral position through the entire cutting cycle at slow speed, reversed and returned to neutral at high speed. The seal was subjected to severe test as large quantities of abrasive dust and chips had to be removed by maintaining 50 to 60 lb. air pressure in inclosed work arbor area.

The seal lip has a rotary-sliding contact with the seal plate and also a wiping action resulting from rotation of the eccentric. The wiping action scrapes the accumulation of abrasive and oil film off the sealing plate, leaving a clean surface under the sealing lip. Spring-adjusting set screws permit varying of the sealing lip pressures to suit different conditions of operation.

The new seal allows complete freedom of the operating mechanism and maintains lubrication by holding a reservoir of oil within the machine. Maintenance takes about one-tenth the time formerly required.

This seal design can be applied where friction loads must be minimized, such as for the protection of roller and ball bearings when they are loose and con-

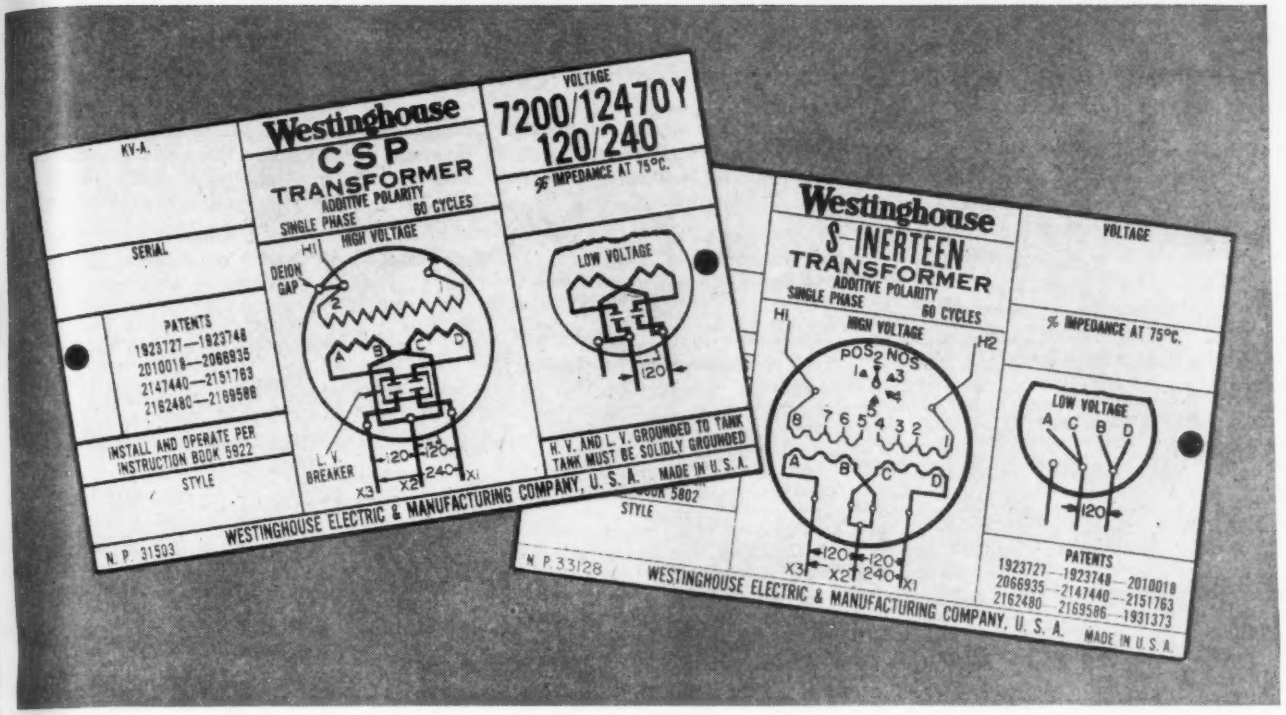




(Above) Two seal designs without spring adjustment for anti-friction bearings. (Left) Flexible sealing unit design for milling head that produces an eccentric cutter path, and design of bellows seal.

centric seals prove inadequate. The bellows seal is effective at varying degrees of bearing looseness and when misalignment or eccentricity is severe.

Various materials can be used for the sealing lip. Neoprene has proved satisfactory when abrasive action is mild and speed comparatively slow. Graphite is a good material for high-speed operation. A good grade of graphite is said to outlast a metal lip many times because of its efficient lubricating action.



Dark symbols on a light background produce light color values, as shown in these acid-etched stainless-steel diagram plates.

Effectiveness of Nameplates Is Determined by Design

B. A. LEE
Nameplate Designer, Westinghouse Electric & Mfg. Company

Various methods of making nameplates are reviewed and their limitations are indicated. Advantages of cooperation between design engineer and nameplate designer that can lead to more effective plates are described.

NAMEPLATES of today are designed to be an integral part of the machines they identify. Their beauty and usefulness depend upon the designer's ingenuity, material and function.

At one time, nameplates were considered neither functional nor decorative, but just nameplates. However, with the trend toward simplicity in construction, operation and appearance of machinery, new methods for manufacturing nameplates naturally followed. The bulky cast-iron and yellow brass nameplates of years ago were too awkward and big to go with the simple lines of these new machines. Therefore, nameplates had to be designed for both appearance and function, which involved new methods of fabrication and the use of new materials.

Methods by which nameplates are made today are acid etching, lithographing, stamping, printing, casting and, in the case of aluminum, anodizing.

Acid etching is adaptable to most metals. For this reason, nameplates are now made of etched aluminum, chromium-plated brass, nickel-silver, Monel metal, and stainless steel. Because of restrictions on these metals, nameplate manufacturers have supplied etched zinc, lead and, more recently, etched plastic. It was quite natural that a process used only on metals should be tried on plastics. With the multi-colored plastics as base materials, there is no limit to color schemes that are possible.

The process of acid-etching as applied to metals is fairly complicated. A black-and-white drawing of the design two or four times as large as the final nameplate is made. The drawing is photographically reduced to the correct size on a glass negative which is then placed on metal that has been treated with a light-sensitive, acid-resisting material. The design is burned by light through the glass negative onto the acid-resistant surface. The burned part is washed away and the remaining resistant material is baked onto the metal for the next operation. The plate is then immersed in acid for a short period, the acid attacking the metal only where the resistant material has been

Guide for the Design and Arrangement of Nameplates

Type of Data	How to Design
General name of apparatus—(A. C. Motor, Oil Circuit, D. C. Generator)	Should be in large type and located prominently, preferably centered at top of plate.
Patent numbers	Must be included and may be utilized to balance design. Should not interfere with more important data. Separate plate can be used, with company name and nameplate numbers below patent numbers.
Made in U. S. A.	"Made in U.S.A." preferably should be as large as the smallest wording on the plate.
Width of trim for etched nameplates	Area of plate, sq. in. / Min. width of trim, in. Up to 2.5 — 0.025 2.5 to 6.0 — 0.031 Above 6.0 — 0.047
Minimum size lettering	The smallest character that can be etched economically is 1/32 in. Lettering on case plates should be no smaller than 1/8 in.
Mounting holes	Holes should be drilled or punched inside the plate so that head of mounting screw will not conflict with lettering or border line.

Area of plate	No. of holes	Size of hole, in.	Screw dia., in.	Dia. of screw head, in.
One dimension				
1 in. or less	2	3/32	0.086	0.172
Up to 8 sq. in.	4	1/8	0.112	0.225
8 to 25 sq. in.	4	5/32	0.138	0.279
25 to 50 sq. in.	4	13/64	0.190	0.385
Above 50 sq. in.	4	9/32	0.250	0.507

Type of Data	How to Design
Blank spaces for variable data—(serial and style numbers, ratings)	Space for data to be engraved, stamped or printed after nameplate has been made should be figured accurately to accommodate equipment.
Length of blank	Example—Length of blank to carry ten digits must be approximately 1 3/4 in. if 0.150-in. standard engraving is used.
Height of blank	Allow for 1 1/2 times height of characters used.
Size	Well-proportioned nameplates should have ratio of width to length of 5:8.

Typical Dimensions Within ± 10 percent of Ratio

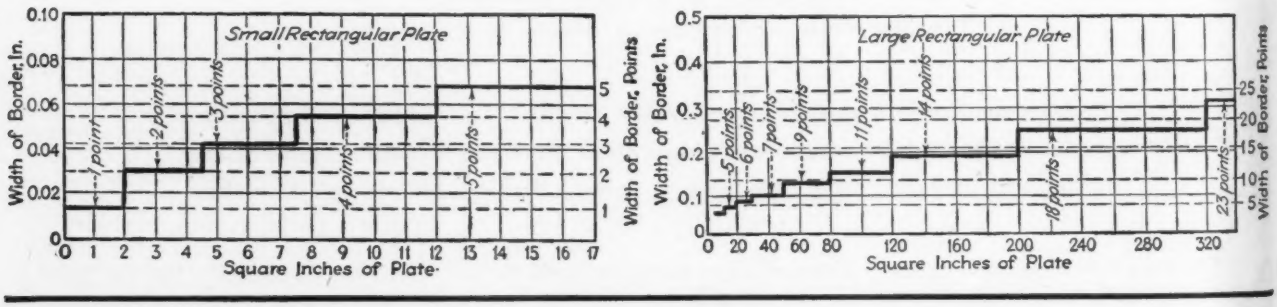
Width	Length	Width	Length
3/16	5/16	1 1/2	2 1/2
5/16	1/2	2 1/2	4 1/8
3/8	9/16	3 1/4	5 1/16
9/16	1	5 1/2	9 1/8
1	1 1/2	6 1/2	10 1/8

Thickness of material etched	Area in sq. in.	Thickness of Material, in.
	Up to 12	0.0226
	Above 12	0.0320

Thicker material is not recommended because it will not remain sufficiently flat after shearing and may crack glass negative.

Cast	Area, sq. in.	Over-all Thickness, in.	Letters, Border and Blanks: Depth of Relief, in.	Letters, Border and Blanks: Draft deg.
	Up to 75	1/8	3/64	15
	75 to 255	3/16	1/16	
	225 to 450	1/4	3/32	
	450 to 875	5/16	1/8	

CHARTS SHOWING WIDTH OF BORDER LINE



burned away. This resistant material is removed and the etched design filled with a baked enamel or an oxide. When the plates have been trimmed and mounting holes punched, a spray coat of lacquer or varnish is applied for protection in handling.

Lithographing is probably the most practical method for reproducing large quantities of semi-permanent nameplates. The process is simple in its operation and nameplates of high quality can be turned out as fast as any printed matter. Materials usually lithographed are aluminum, tin-plated steel and low-carbon steel. The versatile plastics are also adaptable to this process. Lithographed phenolic nameplates equal to metal plates in design and durability have made their appearance.

Stamping, one of the oldest methods for making nameplates and identification tags, is still very much in use. Indentations are pressed into the metal surface with steel dies by hand stamps or hand-operated or automatic stamping machines. Thin metal foils approximately 0.002 in. thick with a paper backing, or heavier foils approximately 0.005 in. thick without paper backing, can be stamped or debossed with pleasing effect. Fine lettering and designs in base-relief can be created. A coat of colored transparent lacquer increases their attractiveness.

Hot-stamped phenolics have found wide acceptance at present in the industrial field. The nameplate design is engraved on a steel die, the face of which is inked by rolls in the manner of a printing press. With the application of heat and pressure, the die indents the surface of the plastic and fills the letters and design in one operation. When variable ratings are desired plug-in dies, similar to printer's type, are used. A slot is cut in the master die, the plug-in dies are inserted

and locked into place. The entire procedure takes a few seconds and a new nameplate complete with changed ratings and data is produced. The plug-in dies eliminate expensive engraving or stenciling.

Printed sticker labels and decalcomanias or transfers are still used for many applications. Although they are not as permanent as other methods their use covers a wide range of inexpensive products. The life of a sticker label or decal can be prolonged by coating it with varnish or lacquer after it has been mounted. These nameplates are usually printed in brilliant colors and are conspicuously placed on the apparatus.

Printed plastics are one of the most popular nameplates to result from wartime substitutions. Any of the thermoplastics can be used. The letters and design are printed on the reverse side of a clear sheet of a thermoplastic material. The printing is covered with a paint containing some of the dissolved plastic in a contrasting color. The nameplate is viewed through the clear sheet, which protects the design from wear. Two or three colors can be used to make a striking nameplate.

Thermoplastics have also been laminated to make a more permanent nameplate. In this procedure a sheet of opaque white or colored plastic is printed with the design. A thin sheet of transparent plastic is then laminated to the printed surface.

Both sprayed and laminated plastic plates can be stenciled or engraved, the same as a metal plate. Thousands of these plates are used today to replace the more strategic materials, and they will probably remain after the war as standard nameplates.

Laminated phenolic has long been a standard material for engraving. It consists of a core of urea-formaldehyde-treated white paper laminated between layers of phenolic-treated black paper. The letters are engraved through the black layer so that the white material can be seen. Thus, no filling of the letters is necessary.

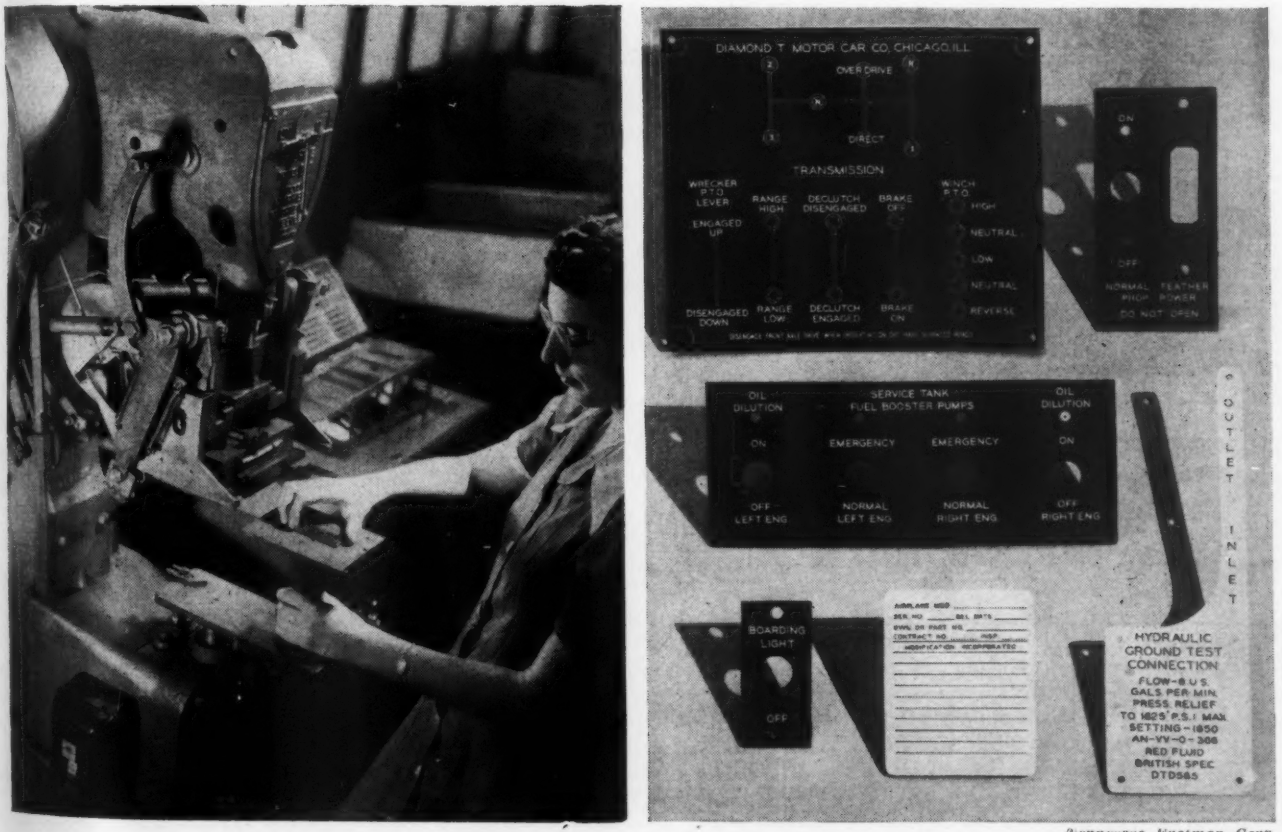
Printed phenolic nameplates have replaced the engraved type where large numbers of duplicate plates are needed. White paper is printed and treated with clear urea formaldehyde. This is then laminated to a heavy base of phenolic-treated black paper. These nameplates can be printed in different colors and can also be engraved.

Cast nameplates made of aluminum, brass, bronze or any of the white metals are used on large equipment, such as steam turbines, generators and furnaces. They are chosen because of their heavy, sturdy appearance and the appearance and the shadow effect caused by the raised, polished letter on a background of contrasting color. Today cast nameplates are made of antimonial lead, zinc and malleable iron in addition to the above materials.

Anodizing is the process by which information is printed on a sheet of aluminum with anodizing ink of any desired color. The whole sheet is then immersed in a solution which electrolytically activates the ink. After a short immersion time the ink or dye has impregnated the aluminum several thousandths of an inch, yet the surface of the metal is still intact. This process renders an attractive nameplate with unlimited color possibilities.

Design Consideration

Most companies that use large quantities of instruction and data plates every year must establish standards on designs and materials. This facilitates assembling several different pieces of equipment into one unit, at the same time retaining similarity of design. Nameplates in this effect must be alike and thus standards for size, thickness



Tennessee Eastman Corp.

(Left) Plastic nameplates are made in a vertical press with steel dies. (Right) Dark color values are produced by using light letters and symbols on a dark background, as these plastic switch plates and panels illustrate. Depressed lettering molded into the extruded plastic sheet is filled with a pigmented synthetic-resin base material and the plates are then fabricated by shearing or die-cutting. Light color values are produced by using dark letters and symbols on a light background.

Types of Nameplates

WROUGHT METAL

Material	Equipment Location	Material Cost	Methods of Fabricating	Approximate Cost Based on Quantities			Use of Color
				100	500	1,000	
Aluminum	Indoor	Low	Anodized	High	Med.	Med.	Unlimited
			Etched	Med.	Med.	Low	Limited
			Lithographed	Med.	Low	Low	Unlimited
			Stamped (cold)	High	Med.	Med.	No Color
Brass	Outdoor	Med.	Etched	High	Med.	Low	Limited
			Stamped (cold)	High	Med.	Med.	No Color
			Etched and Plated (Chromium and Nickel or both)	High	High	Med.	Limited
Lead	Outdoor	Low	Etched	Med.	Low	Low	Limited
Monel	Outdoor	High	Etched	High	High	Med.	Limited
Nickel Silver	Outdoor	Med.	Etched	High	Med.	Med.	Limited
Stainless Steel	Outdoor	High	Etched	High	High	Med.	Limited
Steel, cold rolled	Indoor	Low	Etched and Enameled	High	High	Med.	Limited
			Etched and Plated (Cadmium, Silver, Zinc)	High	Med.	Med.	Limited
			Tin Plated and Lithographed	High	Low	Low	Unlimited
			Tin Plated and Stamped (cold)	High	Med.	Low	No Color
Zinc			Etched	High	Med.	Low	Limited
			Lithographed	High	Low	Low	Unlimited
			Stamped (cold)	High	Med.	Low	No color

CAST METAL

Aluminum	Indoor	Med.	Cast nameplates as compared to etched metal nameplates are approximately 2 to 4 times higher in cost. In lots of 10 or less, the cost is maximum; in lots 25 to 75, 33 percent less; in lots of 100 to 200, 66 percent less.	One or two colors can be applied
Brass or Bronze	Outdoor	Med.		
Brass or Bronze, Chromium Plated	Outdoor	High		
Malleable Iron	Indoor	Med.		
Antimonial Lead	Outdoor	Low		

DECALCOMANIAS, FOILS AND LABELS

Metal Foil: Aluminum or Brass	Indoor	High	Paper-Backed and Stamped	High	Med.	Low	Limited
Decals	Indoor	Med.	Printed or Lithographed	Med.	Med.	Low	Unlimited
Paper	Indoor	Low	Printed or Lithographed	Med.	Low	Low	Unlimited

PLASTIC

Thermoplastic	Indoor	Low	Printed or Lithographed	Med.	Low	Low	Unlimited
			Stamped (hot)	High	Med.	Low	Limited
			Printed or Lithographed and Laminated	High	Med.	Low	Unlimited
			Etched	High	Med.	Med.	Limited
Thermosetting	Indoor	Med.	Lithographed	Med.	Low	Low	Unlimited
			Stamped (hot)	High	Med.	Low	Limited
			Laminated and Engraved	High	High	High	No Color
			Printed and Laminated	High	High	Med.	Limited

of material, width of borders and width of trim are necessary.

In creating instruction plates for commercial equipment, the design engineer and plate designer must discuss the general appearance of the machine. The nameplate material is chosen depending on the location of the machine in operation. If it is to be used outdoors, stainless steel would be most satisfactory; if it is to be located indoors, under adverse conditions such as dampness or smoke and acid fumes, etched nickel-silver or chromium-plated brass would be adequate. If the indoor application is under ideal conditions, etched or lithographed aluminum, stamped metal foil, decals or stickers can be used.

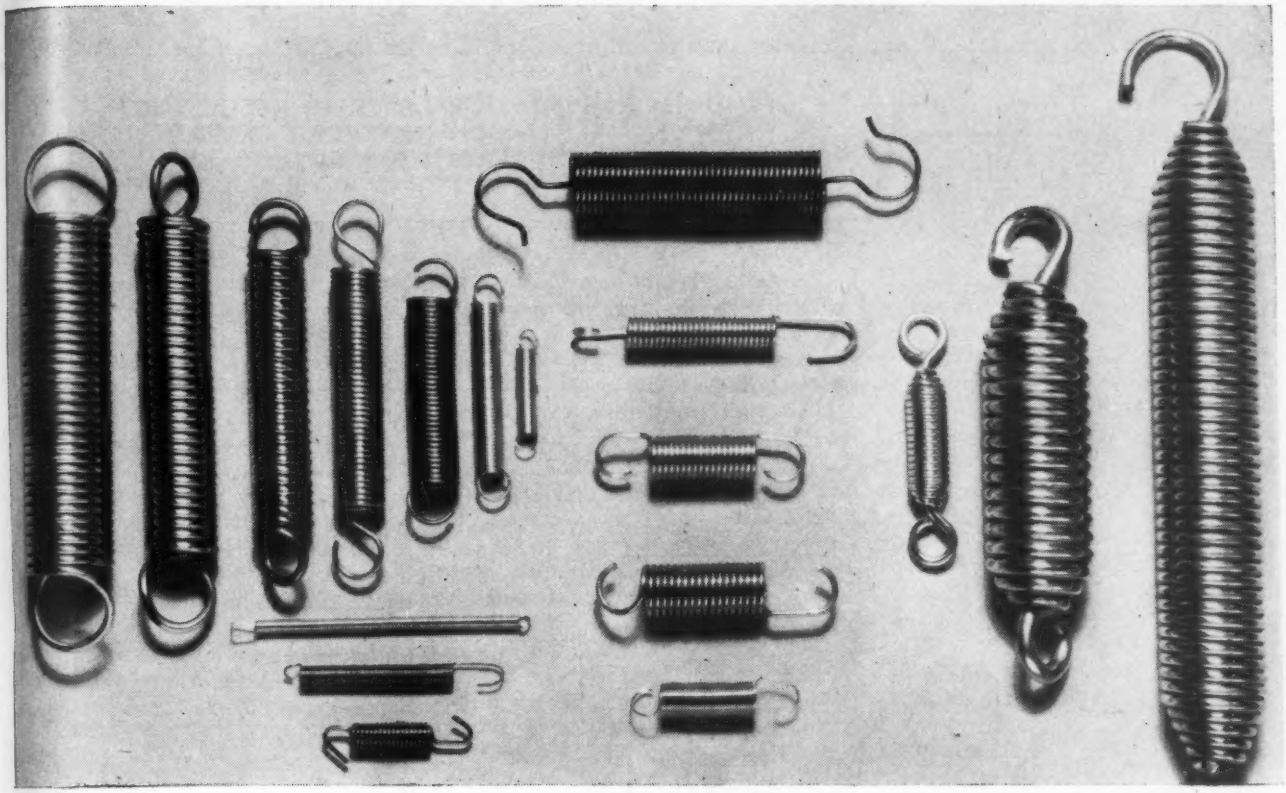
The next factor is the color arrangement. In most cases, the machine will be finished in the natural metal color or painted black, light gray, or aluminum. If the finish is black, the nameplate should be of a dark color value unless it is an advertising or "warning" nameplate. Red, the color symbolic of danger, should be used only on warning nameplates. If the machine is light in color, the nameplate should be light in color value.

This arrangement of having a nameplate blend into the machine is not always the best. In some cases where the lighting is bad or where speed in reading a nameplate is necessary a contrasting namepalte would be most proficient. Other colors can be added to make the plate more attractive. One or two colors should produce the desired effect.

The nameplate designer should first secure from the design engineer complete information regarding the material, color scheme and the necessary rating data. He then draws a sketch of the proposed nameplate in proportions of 2 to 1 or 4 to 1 to the finished plate.

The proposed sketch, with all measurements such as rules and letter sizes given in printers' terms (points or picas), is sent to the printer to be set in type. The printed black-and-white copy should be given any necessary art work and carefully checked for errors. This original black and white is then sent to the nameplate supplier and a copy retained by the plate designer for checking.

Nameplates play a relatively small part in the over-all design of a machine —but small as that part may be, their power to sell and advertise has long been recognized as an all-important factor. Good appearance design, presentation of information or data pertinent to the operation of the machine or for the replacement of parts, correct choice of material and process—all combine in a nameplate to increase the value of any piece of equipment.



Deflection of Coiled Springs Wound With Initial Tension

HAROLD CARLSON
Chief Engineer, Lee Spring Company, Inc.

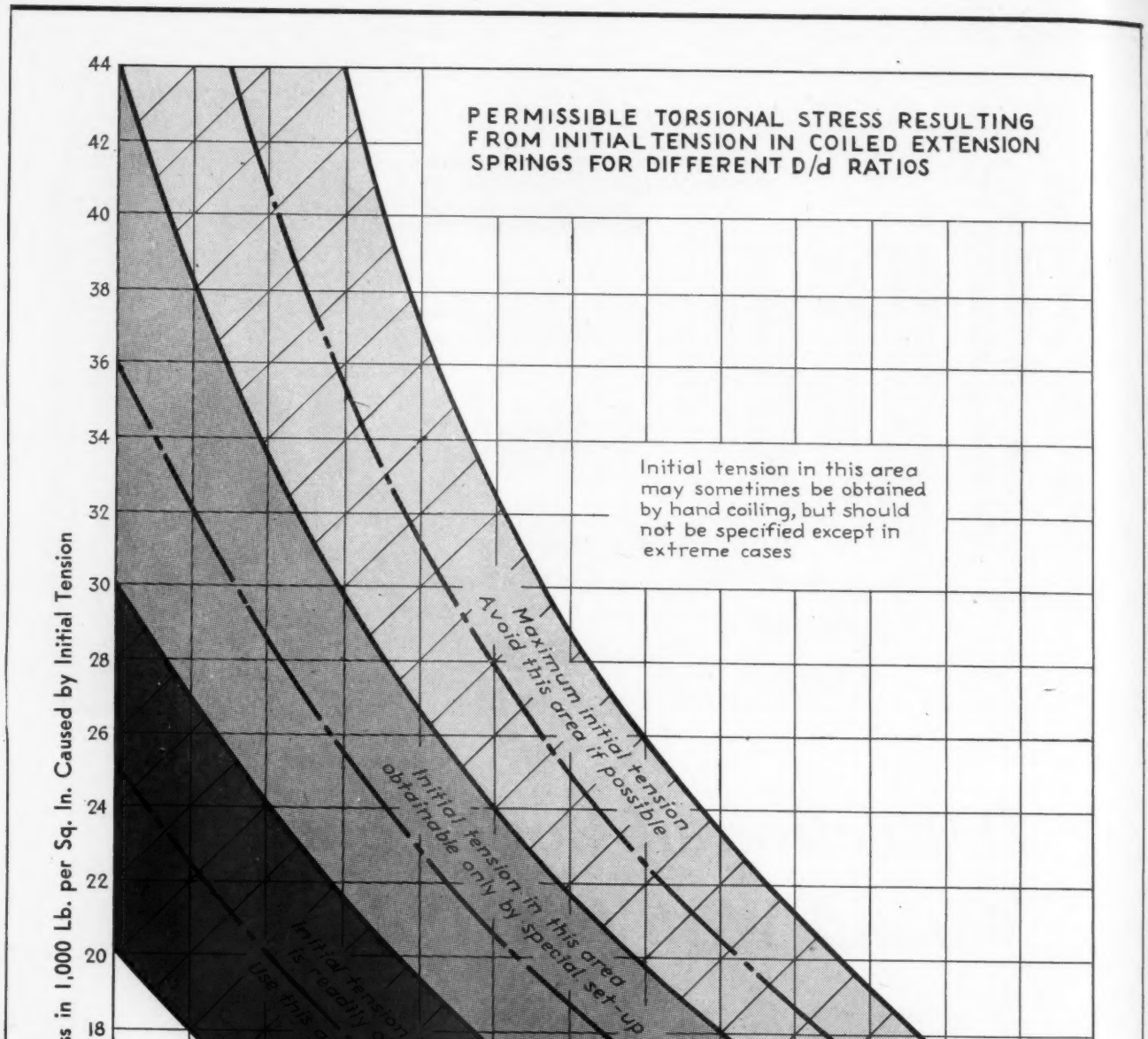
Physical factors and manufacturing considerations that affect the design of coiled springs wound with an initial tension. Formulas for computing deflection and torsional stress are included, also curves derived from test data which indicate range of initial tension obtainable in springs of different coil and wire diameters.

IN THE spring industry, the term "Initial tension" is used to define a force or load, measurable in pounds or ounces, which presses the coils of a close wound extension spring against one another. This force must be overcome before the coils of a spring begin to open up.

Initial tension is wound into extension springs by bending each coil as it is wound away from its normal plane, thereby producing a slight twist in the wire which causes the coil to spring back tightly against the adjacent coil. This is accomplished on automatic spring-coiling machines by making adjustments to the diameter and pitch tools, and has certain limitations depending upon the tools. When springs are wound on special spring-coiling lathes, adjustments are made to the tool holder on the carriage which alter the position and angle of the feed, and vary the holding force on the wire.

Initial tension can be wound into cold-coiled extension springs only. Hot-wound springs and springs made from annealed steel are hardened and tempered after coiling, and therefore cannot be made with initial tension in the coils. It is possible to make a spring having initial tension only when a high tensile strength, obtained by cold drawing or by heat-treatment, is possessed by the material as it is being wound into springs. Materials that possess the required characteristics for the manufacture of such springs include hard-drawn wire, music wire, pre-tempered wire, 18-8 stainless steel, phosphor-bronze, and many of the hard-drawn copper-nickel, and non-ferrous alloys.

Nearly all cold-wound extension springs are coiled with some initial tension to hold the spring together. Obviously, if a long or a heavy extension spring were made without some initial tension, the weight of the spring itself


PERMISSIBLE TORSIONAL STRESS RESULTING FROM INITIAL TENSION IN COILED EXTENSION SPRINGS FOR DIFFERENT D/d RATIOS
Initial tension in this area may sometimes be obtained by hand coiling, but should not be specified except in extreme cases
Maximum initial tension
Avoid this area if possible
Initial tension in this area obtainable only by special set-up
Initial tension in this area is readily obtainable
Use this area wherever possible
Initial tension in this area is difficult to maintain with accurate and uniform results, particularly when approaching low-stress values
Torsion Stress in 1,000 Lb. per Sq. In. Caused by Initial Tension
44
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16
Spring Index = D/d = Mean Dia. / Wire Dia.

would cause the spring to extend. The number of coils in a spring generally does not affect, nor have any relationship to, the amount of initial tension. An exception to this is a spring that is so long that the weight of the spring causes a load that exceeds the initial tension. From a manufacturing viewpoint, it is always desirable to have some initial tension in all extension springs. Springs of this type can be manufactured much more accurately, particularly with respect to the free length requirements.

The amount of initial tension will vary slightly within the coils of each spring, also from one spring to another. This results from microscopic variations inherent in the diameter, concentricity and hardness of the wires, as well as from a slight wear on the coiling tools. When manufacturing large quantities of springs, it is difficult to make each spring with exactly the same amount of initial tension. A tolerance of plus or minus 15 percent on the amount of initial tension is reasonable and is considered standard. This tolerance can be reduced to plus or minus 10 percent where necessary, but this reduction may cause an increase in manufacturing time and consequently an increase in cost. Further reductions in this tolerance may increase the cost of the spring as much as 50 percent.

When a load strong enough to overcome the initial tension has been applied, a spring will deflect in a theoretical straight line curve with a uniform rate. For example, suppose the initial tension is 5 lb. and the rate or load for each inch of deflection is 10 lb., then

At a deflection of 1 in., the load is
$(1 \times 10) + 5 = 15$ lb.
At a deflection of 2 in., the load is
$(2 \times 10) + 5 = 25$ lb.
At a deflection of 3 in., the load is
$(3 \times 10) + 5 = 35$ lb.

and conversely

Deflection with a load of 20 lb. is
$(20 - 5)/10 = 1.5$ in.
Deflection with a load of 30 lb. is
$(30 - 5)/10 = 2.5$ in.
Deflection with a load of 40 lb. is
$(40 - 5)/10 = 3.5$ in.

It will be observed from these figures that an extension spring with initial tension will deflect at a uniform rate after the initial tension has been overcome.

A quick and easy, although not too accurate, method of measuring the amount of initial tension is to place a spring on a spring testing scale and cause a slight extension to take place. The extension can be determined by placing a very thin feeler between the coils or by reading the deflection indicating gage. The load reading on the testing scale will be very close to the initial tension load.

A more accurate method is to place a spring on a spring-testing scale and then:

1. Extend the spring any convenient amount (such as 1 in.), and measure the load.
2. Extend the spring exactly twice that amount (in this case, 2 in.), and again measure the load.
3. Subtract the first load from the second; subtract this difference from the first load and the remainder obtained is the exact amount of initial tension.

The amount of initial tension that can be wound into an extension spring depends primarily upon the spring index as well as upon the type of material. The spring index is the ratio of the mean diameter D, divided by the wire diameter d, or D/d. As this ratio becomes smaller, more initial tension can be produced.

It should be remembered, that as the spring index is reduced the deflection of a spring is lessened. Also, the more the initial tension is increased, the smaller the deflection. For example, if an extension spring is wound without initial tension and the torsional stress is 60,000 lb. per sq. in. at a load of 40 lb., the deflection might be four inches. But the same spring if coiled with 10 lb. of initial tension would have a torsional stress caused by initial tension of

$10 \times 60{,}000/40 = 15{,}000$ lb. per sq. in.

and a deflection of

$(40 - 10)/10 = 3$ in.

Although the deflection of the second spring is less, the final stress and final load will be the same as in the first spring, and the rate per in. of deflection after the initial tension has been overcome will be the same for both springs, namely, 10 lb. per inch.

This example indicates clearly that springs wound with initial tension cannot be deflected so far as can springs wound without initial tension. This should be considered in the design of the spring. It should also be borne in mind that tightly wound springs will lose a portion of their initial tension if deflected too far, and that overstretching the spring will remove all of the initial tension inasmuch as the spring would then be stressed to a point beyond the torsional elastic limit of the material.

Inasmuch as initial tension is generally measured in pounds, it can also be transposed into terms of torsional stress in lb. per sq. in. When the amount of initial tension T in pounds is specified, the torsional stress S_{it} caused by load T can be calculated by

d = wire dia., in.
t = thickness of square wire, in.
D_o = outside dia. of coil, in.
$D = D_o - d$ = mean coil dia., in.
D/d = spring index ratio
T = initial tension, lb.
P = load on spring, lb.
S = torsional stress, lb. per sq. in., caused by a load of P lb.
S_{it} = torsional stress, lb. per sq. in., caused by initial tension of T lb.

For round wire $S_{it} = \dfrac{8\,TD}{\pi\, d^3}$

For square wire $S_{it} = \dfrac{TD}{0.416\, t^3}$

Also, the torsional stress S_{it} caused by initial tension T can be computed by proportion when the torsional stress S caused by a known load P has been calculated

$$S_{it} = S\,T/P$$

The torsional stress caused by initial tension must be added directly to the torsional stress resulting from the deflection in order to determine the total torsional stress. This total should then be corrected for curvature by the usual method to determine the true total stress in the spring.

Extension springs wound with initial tension may or may not be heated after coiling to relieve residual stresses induced by forming the coils. Heating steel springs between 450 to 500 deg. F. will cause a loss of from 25 ot 50 percent of the initial tension. This loss must be allowed for during the coiling operation.

The amount of initial tension that may be readily wound into an extension spring on standard automatic spring coiling machines may be estimated to be roughly 25 to 33 percent of the maximum load that the spring can safely exert.

Another empirical formula to determine the permissible torsional stress caused by initial tension for steel springs is

$$S_{it} = \frac{100{,}000}{D/d}$$

Tests on a variety of springs indicate that the values obtained by this formula are fairly accurate. But the value obtained from this formula can, in some instances, be doubled and tripled. The curves in the accompanying chart have been made up from the results of tests on many springs. By hand-coiling with special tools, even larger amounts than shown on the curves have been obtained. Such methods should not be considered standard practice as they are the exception rather than the rule, are laborious and require extra manufacturing time. The curves are quite detailed, and need no further explanation. It might be well to point out, that aiming for the center line of a curve in preliminary calculations will save designing time.

The values in the curves in the chart are for springs made from spring steel. They should be reduced 15 percent for stainless steel, 20 percent for copper-nickel alloys and 50 percent for phosphor bronze and other non-ferrous materials.

Standards For Surface Quality And Machine Finish Designation

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Setting forth possible effects of surface quality on strength and functioning of machine or structural members. Surface irregularities that define quality, methods of measuring roughness and standard roughness values are described. Methods for designating on drawings the standard surface finish required will be covered in a following article.

THE trend in engineering design is toward greater exactness in all calculations and specifications. The purpose is to achieve at minimum cost the ultimate in product functioning, durability and appearance. One of the many requirements to attain this objective is that the surface finish be of a certain desired quality but not needlessly fine, as this adds to the cost without contributing increased value.

Up to a few years ago the general attitude toward surface finish was to allow as rough a surface as obvious conditions would permit. The qualities of the finish were not specified in measurable quantities, but in ambiguous terms such as "machine finish," "file finish," "grind," "buff," or simply "smooth machine finish." Opinions, usually based on the appearance of the surface, determined whether the finish was acceptable. Often decisions were made by balancing the over-all maintenance cost of a low quality surface against the additional initial cost of extra machine or hand operations that are necessary to assemble the parts and to assure satisfactory performance of the machine.

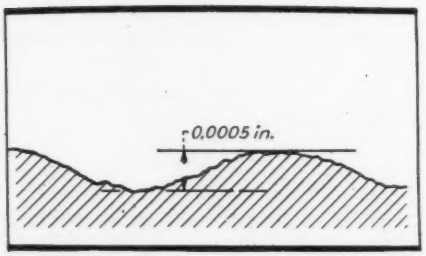

Fig. 1—Waviness is that deviation from a nominal surface over and above the finer irregularities called roughness. Here the depth of the wave is 0.0005 in. There is no definite demarcation between waviness and roughness.

Assembly requirements are not the only criteria for quality of surface finish. The degree of surface roughness of machine parts may affect their properties and performance in many ways. Among them are the following:

1. Friction between both lubricated and unlubricated surfaces is largely determined by surface roughness.

2. Wear, particularly initial wear, is much more rapid for rough surfaces than smooth ones.

3. The function of moving parts often will be seriously affected by surface conditions. Chrome-plated engine cylinder walls may be so smooth that lubricating oil will not adhere and failure will result. Rough piston rods score packings and prevent proper sealing. Sliding fits may stick if the surfaces are too rough or gall if they are too smooth.

4. Fatigue strength is greatly affected by the character and roughness of the surface. Sharp deep scratches cause stress concentration and reduce the fatigue strength considerably.

5. The rate of heat transfer is increased by roughening the surface. Heat insulation is improved by making the surface smoother.

6. The optical properties of mirrors, lenses, and reflectors are largely dependent upon surface smoothness, which affects light transmission, reflection and refraction.

7. The appearance of a surface is largely a matter of smoothness. The brilliance of an electroplated coating is determined not only by the smoothness of the surface before it is plated but also by the polishing operations subsequent to plating.

To the seven considerations above could be added an indefinite number applicable in various fields of specialized design. An example is the dependence of aerodynamic qualities on surface smoothness, as in projectiles, airplane propellers and the leading edges of laminar flow wings for high-speed aircraft. As another example, polished stainless steel is highly resistant to corrosion whereas unpolished stainless steel rusts when exposed to the atmosphere.

Factors That Affect Quality

The quality of a surface is determined by many factors, including the magnitude and type of flaws, the soundness of the surface, the surface configuration of the random irregularities and the direction or lay of the predominant tool marks. All of these can be determined qualitatively by visual inspection and the quality of the surface, so far as these factors are concerned, can be definitely specified without requiring special measurements. In addition to these factors, the depth of the scratches or tool marks, the distance between peaks of the scratches, the waviness of the surface and the degree of uniformity of the roughness will determine the quality of the surface.

Experience and tests have shown that the surface of materials finished by milling, turning, grinding, and other shop operations will be, for all practical purposes, of the same quality if each has substantially the same waviness and roughness. That is, such surfaces will

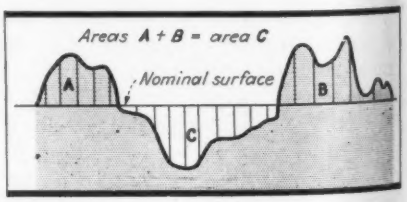

Fig. 2—The nominal surface is the geometrically perfect and smooth surface that would result if all the peaks and hills were levelled off to fill the valleys.

perform with equal satisfaction. The problem is further simplified in that only rarely is it necessary to specify either waviness or lay simply because parts normally produced by any experienced operator using machine tools and cutters in good condition will be satisfactory for most applications, so far as these two factors are concerned. Hence, the problem is primarily reduced to establishing a method for measuring surface roughness quantitatively and a means for specifying on the drawings the maximum allowable roughness.

Definition of Roughness

Roughness refers to those recurrent irregularities that normally cover the surface completely. For the most part, the roughness determines both surface appearance and its suitability for its purpose, although it should be emphasized that appearance cannot be used as a basis for judging comparative roughness.

In order to give an idea of the magnitude of the roughness, the distance between crests or high spots of a "smooth machined surface" is usually between 0.002 in. and 0.010 in. and seldom exceeds 0.040 inches. Their height is usually much less, being between a millionth of an inch and 0.0005 in. Of course the corresponding dimensions of surfaces which are rougher than those classified as "smooth machined" will be proportionately larger.

Although waviness is not usually a critical factor, the possibility of its being so should always be considered. Waviness, as shown in Fig. 1, is that deviation from a nominal surface (over and above the finer irregularities called roughness) having the form of waves. The magnitude of waviness is the vertical distance from crest to valley, as indicated. The "nominal surface" is defined as the geometrically perfect and smooth surface that would result if all the peaks and hills were leveled off to fill the valleys, as indicated in Fig. 2. The conventional dimensions and tolerances given on drawings define the shape and location of the "nominal surface." The deviations referred to as waviness are usually of greater magnitude than roughness, which may be superimposed on waviness.

Although there are many ways to measure surface quality, we owe the greater part of our progress along these lines to the development of the Profilometer, shown in Fig. 3 and the Brush Surface Analyzer, Fig. 4. These instruments provided enough information on surface roughness measurement and surface configuration to permit the American Standards Association, the Society of Automotive Engineers and the National Aircraft Standards Committee to establish tentative nomenclature for surface roughness designation and to establish quantitatively expressed roughness standards.

These two pioneer instruments, the Brush Surface Analyzer and the Profilometer, translate surface irregularities into values that serve as suitable indices of surface roughness. Both of these instruments fall in the tracer point classification of surface measuring devices. They are both equipped with small diamond cone tracer points that are suitably mounted in electric pickup units, and, upon being drawn along the surface to be measured, create an electrical

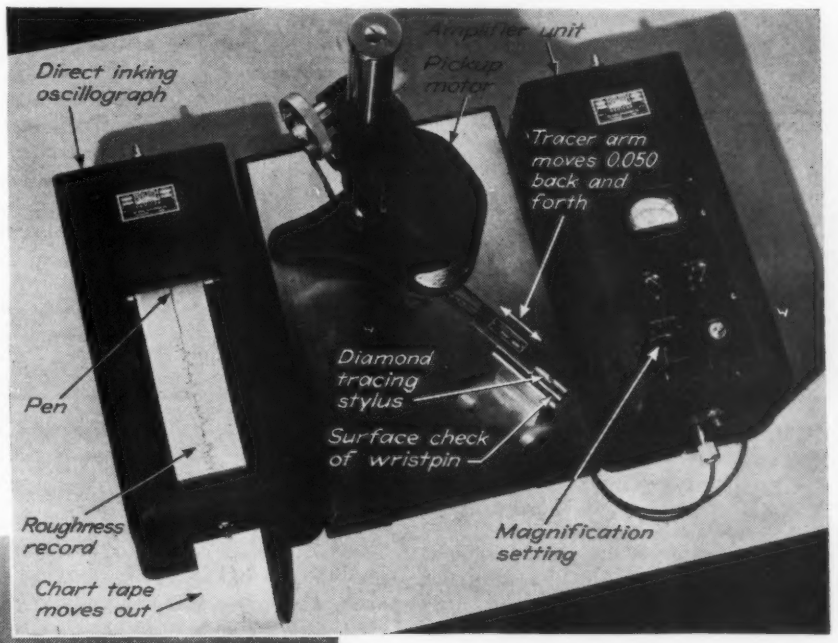

Fig. 3 — (Below) Profilometer. Diamond tracer point mounted between skids at end of pickup unit is slowly reciprocated back and forth over inside rough bearing surface by mototrace. Electric impulse from pickup unit is amplified by Profilometer circuit and gives index to roughness by reading of microinch meter whose full scale calibration may be set as required.

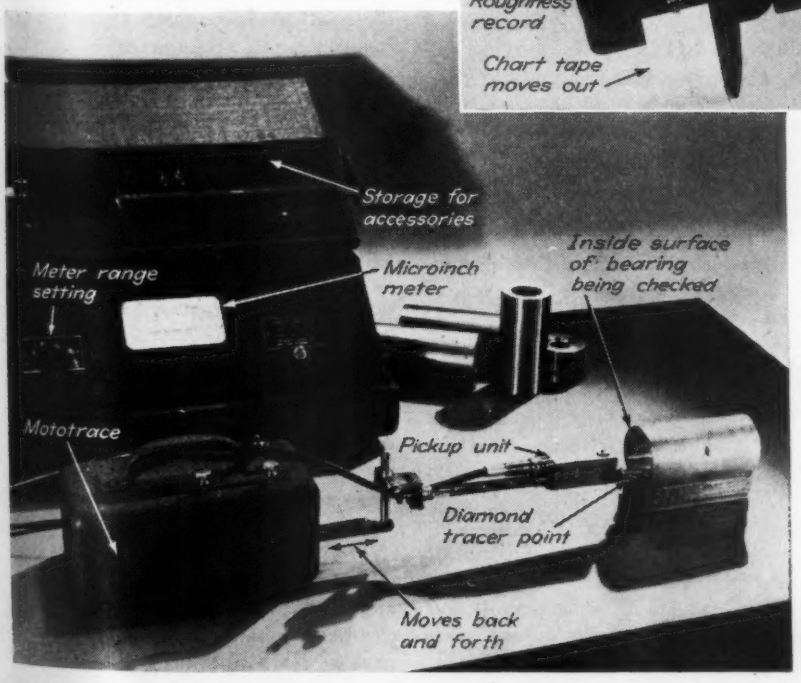

Fig. 4—(Above) Brush Surface Analyzer. Pickup motor moves tracer arm and diamond stylus back and forth over surface of wrist pin. Electric impulse from pickup crystal is amplified preset amount and oscillograph pen traces interpretation of surface roughness on moving record tape for comparison, permanent record, roughness determination and further study.

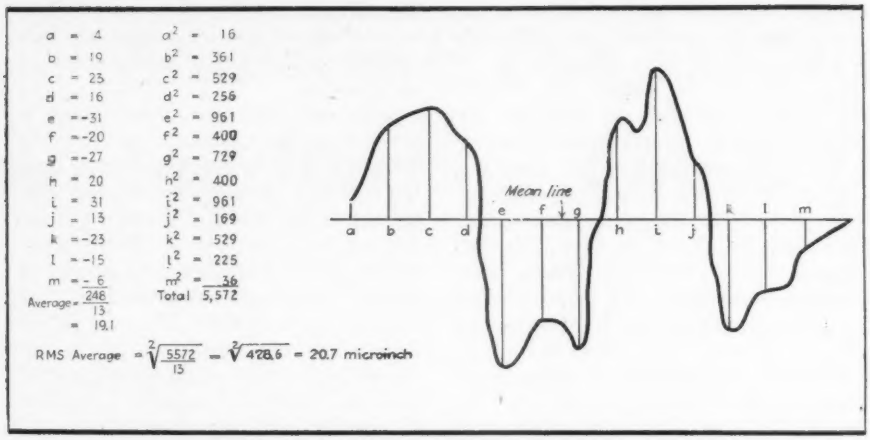

Fig. 5—Method for calculating the root mean square or RMS of a surface contour.

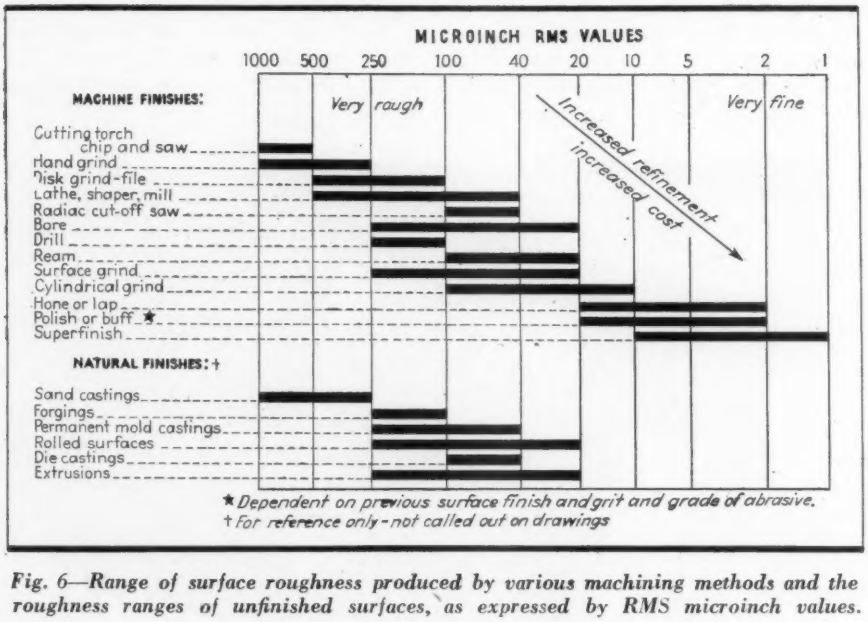

Fig. 6—Range of surface roughness produced by various machining methods and the roughness ranges of unfinished surfaces, as expressed by RMS microinch values.

impulse, similar to that from a phonograph pickup unit, which is amplified to give a roughness reading. The Brush Analyzer traces a wavy line on a chart tape that duplicates at a greatly enlarged scale (as much as 40,000 times) an interpretation of the actual surface contour of the surface being measured. The chart can then be used for comparison and further study and can be kept as a permanent record. The Profilometer uses the amplified electric impulse to operate a meter the reading of which gives a numerical value serving as an index to the roughness of the surface measured.

In order to make the readings of the Brush Analyzer and the Profilometer serve effectively as a basis for the measurement of surface roughness, it was first necessary to adopt a standard unit upon which to base such measurements. In Fig. 5 is shown schematically a typical surface profile. The horizontal axis labeled "*mean line*" represents the nominal surface and is the center of gravity axis of the curve. That is, the areas above the axis are equal to the areas below the axis. In studying such surface graphs, Dr. E. J. Abbott, inventor of the Profilometer, was impressed by the fact that high narrow peaks in such a curve would materially affect the surface quality although they would have little effect in shifting the gravity axis. He concluded that a more accurate measurement of the surface roughness would be indicated by the "root mean square" of the ordinates above and below the mean line. Such a figure would give more weight to high narrow peaks in the surface contour than would an arithmetical average. For all practical purposes, the "root mean square" value or RMS value can be thought of as a weighted average unit of measure of the roughness of a surface that is affected more by the highest and lowest deviations from the nominal surface than by the minor variations. Fig. 5 indicates the method for calculating the root mean square for a given surface contour.

Much has been said both for and against the RMS value regarding its suitability as the unit of measure of surface roughness. There are many who prefer the use of the arithmetical average because of its relative simplicity. As there is little difference between them either would provide a suitable index to the surface roughness.

Although the standards societies have set up tentative standards based on RMS values there appears to be a definite trend toward the future adoption of the arithmetical average value. Dr. George Schlesinger, of the Research Department of the Institution of Production Engineers of Great Britain states that they "hope that our (their) proposal (to standardize on the use of the arithmetical average) will be accepted by American manufacturers and scientists." (Quoted from the American Edition of his book on surface finish, published by the A.S.M.E., January 1942).

If several normal machined surfaces have the same RMS or arithmetical average value, they will ordinarily be equally suitable for a given application. Even though it is possible to imagine freak surface contours that would have the same RMS value and widely differing characteristics, each ordinary machine finish has a typical surface geometry. This makes it possible for one to recognize a ground surface or a turned one. If the RMS value is correct such surfaces will usually perform satisfactorily.

Obviously, it would be extremely cumbersome to use inch values in any arithmetical calculations or in any designation of surface roughness because of the many decimal points that would be involved. For this reason, it was decided that dimensional measurements should be expressed in the microinch unit (one microinch equals one millionth of an inch). The standards associations have chosen this as the basic unit for surface roughness measurement. This unit is perfectly suited for such measurements because the roughness values of practically all critical machine surfaces can be expressed in microinches using simple positive integers, whether an RMS average value is desired, or an actual peak to valley distance, that may, on occasion, be used as a surface roughness criteria.

Standard Roughness Numbers

The National Aircraft Standards Committee has selected a series of standard surface roughness numbers which express the maximum allowable roughness in RMS microinches, for the use

of all aircraft manufacturers. These standards cover the range of aircraft requirements. They are limited in number and range from 500 to indicate extreme roughness to 1 to indicate extreme smoothness. The chart, Fig. 6, shows the range of roughness that may normally be expected of the various machining methods.

500 RMS microinch extremely rough surfaces are produced by heavy cuts and coarse feeds in milling, turning, shaping and boring; rough filling, rough disk grinding and snagging. The unmachined rough surface of some steel forgings and sand-castings fall in this classification. The 500 microinch RMS surface can be used on secondary parts not subject to vibration, fatigue or stress concentration, and parts where margins of safety are high and failure would not endanger safety. Surfaces of such roughness are quite suitable for clearance surfaces on jigs and fixtures where it is just a matter of removing excess metal. Such a finish is not generally advisable for aircraft parts.

250 RMS microinch surfaces definitely show tool marks resulting from a rapid feed in producing a medium machine finish. This surface can also be produced by the coarsest surface grind, a medium file, a smooth disk grind, and similar operations. Scratches caused by chips will not be cause for rejection unless present in excessive size and number.

This surface, by far the most popular for general use, is normally specified for all aircraft applications where stress requirements, appearance, and conditions of operation and design permit. It can be used as a rough finish for aluminum and other soft alloys and on surfaces of cut extrusions, such as clips and braces. It is used on steel and hard alloys where moderate notch sensitivity is permissible and a rough finish is tolerable otherwise. It is suitable for the external surfaces of landing gear parts, hydraulic struts and surfaces in moderate tension where rougher finishes are more acceptable than on parts subject to flight loads. The 250 RMS microinch surface is often used for structural parts having normal margins of safety that are not critical in fatigue and for very deep bores that do not require a special finish from a functional standpoint.

100 RMS microinch smooth machine finishes are produced by high-grade machine work in which relatively high speeds and fine feeds are used in taking relatively light cuts with well-sharpened cutters. All methods of direct machining will produce this surface under proper conditions, including coarse surface and cylindrical grinding, smooth disk grinding and smooth hand filing by a good mechanic.

This surface is suitable for use on main structural fittings and machined terminals subject to flight loads and vibration such as wing and tail surface fittings, control fittings and control surface parts. It should not be used on highly stressed parts of the primary structure, failure of which would endanger the airplane. It is the coarsest finish allowable for bearing surfaces and can be used only where motion is slow and loads are light or infrequent. It is suitable for use where close fits are required as in internal machine parts. It can be used for all stressed parts except rotating shafts, axles and parts subject to severe vibration or extreme tension. It is also suitable for short inside bores on highly stressed parts subject to vibration or flight loads and for structural parts cut from extrusions or from sheets that are more than 0.250 in. thick.

40 RMS microinch surfaces correspond to the finest machine finish, a carbide or diamond bore, a medium surface and cylindrical grind, a rough emery buff, ream, burnish and similar operations. This finish, in the case of turned parts, is usually obtained by removing fine tool marks by subsequent hand work with fine emery cloth. On flat parts an equivalent surface can be produced by a power-sanding machine and fine grit belt.

In specifying the 40 RMS finish, and finer ones, careful consideration should be given to increased shop costs. The 40 RMS finish is used where stress concentration is high or on the external surfaces of cylindrical parts that are highly stressed by flight loads, or are subject to vibration. It is quite difficult to produce on a lathe, mill or other similar machining operation. A 40 RMS finish is relatively easy to produce by centerless or cylindrical grinding, or by surface grinding, and is the most suitable finish for hardened steel. It can be used for bearings where motion is not continuous and loads are light, providing the lay is in the direction of motion, and can be used, if required, on all stressed parts except extreme tension members, such as engine mount bolts.

20 RMS microinch finishes are produced by fine cylindrical grind, a smooth ream, fine surface grind, smooth emery buff, coarse hone, or a coarse lap. This finish is seldom specified except where surface finish is of primary importance for proper functioning of the part. Typical applications are rapidly rotating shaft bearings, heavily loaded bearings, and extreme tension members. It is the type of finish required for static sealing rings, bottoms of ring grooves, and similar applications.

10 RMS microinch finishes are made by the finest cylindrical grind, microhone, hone, lap, or buff. It is specified only when coarser finishes are known to be inadequate, such as the interior honed surfaces of hydraulic cylinders. It is significant that 10 RMS and finer finishes may have either a dull or bright appearance, depending upon the method used to produce them. Appearance of the surface is not a dependable basis on which to judge quality.

5 RMS microinch surfaces can be produced by a hone, lap, Superfinish, very fine buff or bright polish. It is an expensive surface to produce and therefore should not be specified unless such a degree of surface refinement is absolutely essential. In aircraft design it is required only in cases where packings and rings must slide across the direction of the finish grain as on chrome-plated piston rods.

Designating Allowable Roughness

With a knowledge of past and existing practices that have resulted in surface finishes which have given a creditable performance, it is possible to select the maximum allowable RMS microinch roughness advisable for any specific application. The next step is to adopt a method whereby the surface quality demanded can be specified on the drawing. The method selected must be clear and simple and one that will enable the production man and the inspectors to know the exact surface quality desired. Such a method must also readily permit certain surfaces to be designated for special care, so that only those that are critical, so far as roughness is concerned, will be given the extra care in finishing, thereby doing away with the unnecessary refinement of non-critical surfaces.

Finally, a practical shop method for checking the surface produced against the quality specified must be provided.

The inspection method used must be of such a nature that the average machine operator or shop foreman will be able to determine quickly whether or not the surface produced is within the limiting roughness specified on the drawing.

EDITOR'S NOTE— The second article of this series by Mr. Broadston, to appear in the October number of PRODUCT ENGINEERING, will describe in detail a method for indicating on the drawings, the allowable surface roughnesses and will also describe a simple inspection method for checking the surface roughness.

Regenerative Braking Methods For Stopping Electric Motors

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Basic considerations involved in the application of regenerative braking methods to a.c. induction motors, synchronous motors, and d.c. motors, with a brief summation of the inherent advantages and disadvantages of the methods. Also typical control circuit diagrams and curves of regenerative torque.

REGENERATIVE braking is similar to dynamic braking in that the motor acts as a generator except that in regenerative braking the motor is not disconnected from the line but is loaded by feeding its own generated power back into the line.

Plugging and dynamic braking methods were discussed in previous articles, "Electric Braking Methods—Reversal of Power by Plugging," July, PRODUCT ENGINEERING, and "Dynamic Braking Methods for Stopping Electric Motors," August, PRODUCT ENGINEERING.

A.C. INDUCTION MOTORS. If an induction motor is driven above its synchronous speed, it becomes an induction generator and feeds power back into the supply line. Considerable retarding force is effective at slight increases above synchronous speed. The regenerative braking curves of an induction motor are similar to its motoring performance curves except that they are inverted, extend in the negative torque direction and begin at and extend upward from synchronous speed, as shown in Fig. 1. Regenerative braking curves are simply extensions of the normal speed torque curves. Thus an overspeed

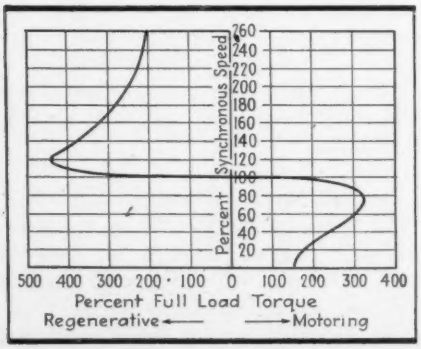


Fig. 1—Approximate regenerative braking torque curves for a typical squirrel-cage induction motor.

equal to full load slip as a motor, will create a retarding force equal to full load torque. In wound-rotor motors the retarding torque at any speed above synchronism can be changed by adjusting the secondary resistors.

If a multispeed motor is operating at one of its higher speeds and the pole arrangement is changed to a lower speed set-up, it will slow down by regenerative braking to a speed proportional to the new and slower set-up.

Regenerative braking of an induction motor is an inherent characteristic that requires no extra equipment. Unfortunately, though useful as a retarding force to prevent dangerous overspeeding, it simply does not exist at speeds below synchronism.

SYNCHRONOUS MOTORS. Since a synchronous motor is essentially the same in construction and design as a synchronous generator, it will act as a generator if driven by its own load and will feed power back into the supply system. Direct coupling of synchronous motors to drives which may be overhauling, are almost unheard of, but they are frequently used to drive d. c. generators which in turn supply power to d.c. motors attached to such loads. When overhauled, the driving motor acts as a generator, reversing the flow of power and driving the d.c. generator as a motor, which in turn drives the synchronous motor as a generator, thus finally pumping a.c. power back into the supply line.

The synchronous motor does not change speed, but simply shifts the angular displacement between its rotating and stationary members in such a way as to return power to the line. The amount of overhauling torque which a synchronous motor can thus retard by regenerative braking without being forced out of, and above synchronism, is approximately equal to its pull-out torque as a motor. This characteristic is inherent, therefore no extra control equipment is required.

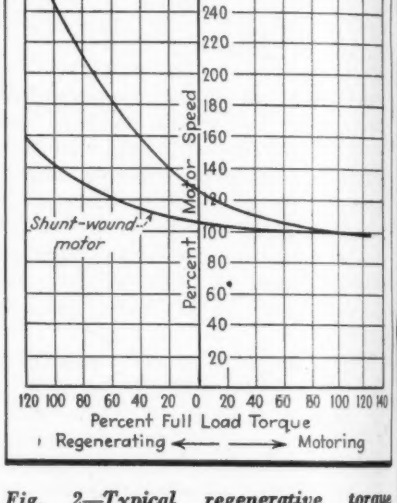


Fig. 2—Typical regenerative torque curves for a shunt-and a compound-wound d.c. motor.

D. C. SHUNT-AND COMPOUND-WOUND MOTORS. If an overhauling load drives a d.c. motor above its rated no-load speed and the motor field remains unchanged in strength and polarity, the self-generated back voltage becomes greater than the impressed voltage and power will flow back into the power supply line. Curves for shunt-and compound-wound d.c. motors are shown in Fig. 2. With motors having a shunt field, regenerative braking is thus an inherent characteristic at overhauling speeds and no extra equipment is required. Retardation at lower speeds can be achieved by increasing the field excitation, thus lowering the speed at which regeneration takes place.

D. C. Series Motors. As in dynamic braking, regenerative braking of a series motor presents a different problem. If such a motor is overhauled it loses its load and its excitation and hence not only becomes incapable of regenerative braking but will run away. Therefore for regenerative braking of loads that are apt to be overhauling, the motor and control is so arranged that the series field is connected across the line as a shunt field. This is common practice on crane applications, which in the lowering direction are arranged for regenerative braking with emergency dynamic braking for the final stop. When the armature current reverses in a shunt or compound wound motor, the polarity of the shunt field remains unchanged, but in a series motor, reversing of the armature current kills the field, unless the control is arranged to maintain the same field polarity regardless of the reversed armature current.

Conclusion. Although plugging, dynamic braking, and regenerative braking are functionally overlapping to some extent, they are sufficiently different in their natures and in their fields of application as to make a clear cut comparison rather difficult. Furthermore, since regenerative braking is an inherent characteristic above certain speeds (except in series-wound d.c. motors) and thus automatically exists in addition to any other type of braking which might be used, any real choice must lie between plugging and dynamic braking.

Plugging of wound-rotor induction motors may be used for the type of overhauling speed control known as counter-torque lowering, but the counter-torque curves of wound-rotor motors are quite steep resulting in wide speed variations for slight changes in overhauling torque so that the speed control by this method of retardation is unsatisfactory for many applications. Plugging is thus most useful as a means of stopping and reversing.

Dynamic braking is effective for stopping and also for securing smoothly controlled retardation under overhauling conditions. Squirrel-cage induction motors and synchronous motors are constant-speed machines so that with them the only concern is with stopping and, perhaps, reversing. D.c. and wound-rotor induction motor applications may require a closely controlled retarding speed, in which event the dynamic braking effort is varied by adjusting the control resistors which are part of the ordinary motoring speed control equipment.

With series-wound d.c. motors, overhauling loads are lowered by regenerative braking and finally stopped by dynamic braking, necessitating special connections for controlling and exciting the field.

In general, for all-electric braking it is logical to plug a squirrel-cage induction motor, to brake dynamically a synchronous motor or a d.c. motor having a shunt field, and also to apply plugging for a wound-rotor induction motor unless the application justifies the expense and requires the refinement and closely regulated retardation provided by dynamic braking. A d.c. series motor would be retarded by regenerative braking, dynamic braking, or a combination of the two.

The accompanying chart and diagrams sum up briefly the advantages and disadvantages of the regenerative method of electric braking.

REGENERATIVE BRAKING

Advantages

No extra equipment is required except for series-wound d.c. motors. Can be made effective with d.c. motors at reduced speeds by strengthening the motor field, that is, by lowering the speed at which the motor will regenerate.

Disadvantages

Effective only at overhauling speeds. Useless as a means of stopping.

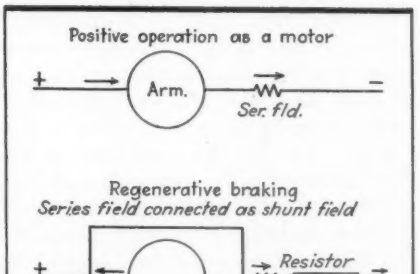
Where d.c. motors must be made to regenerate at low speeds, the control becomes involved and expensive. The motor may require special fields.

SERIES-WOUND D.C. MOTOR MAIN CIRCUITS ONLY

Since regenerative braking at overhauling speeds is an inherent characteristic of all conventional a.c. motors and of all except series-wound d.c. motors, no explanatory diagrams are necessary except for the latter.

In regenerative braking and dynamic braking of series motors, the field and the armature are reversed in respect to each other as compared with their relative polarities under motoring conditions.

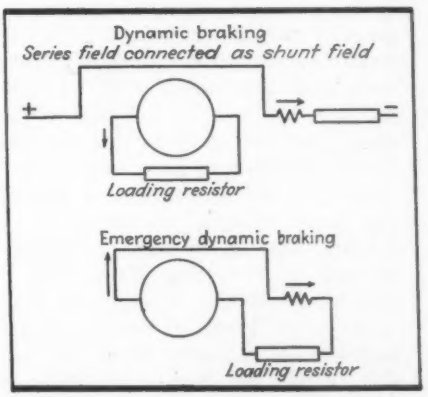
As arranged for regenerative braking, the series field is shown connected across the power supply line as a shunt field and in series with a resistor for adjusting the field current. An overhauling load will drive the motor as a generator and power will flow back into the line. If the load is not overhauling, the motor will function as a shunt motor and will drive itself and its load.



SERIES-WOUND D.C. MOTOR DYNAMIC BRAKING

In dynamic braking the field is connected as for regenerative braking but the armature is disconnected from the line and is connected through a closed loading resistor circuit.

In emergency dynamic braking the motor is entirely disconnected from the line. The field, which must have been previously excited and with the same polarity, is reconnected into the armature circuit and in series with a loading or braking resistor. The motor then acts as a self-excited generator and is independent of the power supply system.



Some applications such as crane hoist equipments, in the lowering direction make use of a combination of motoring, regenerative braking, and finally of emergency dynamic braking in addition to a spring set mechanical brake. The stopping is thus independent of the power supply, this feature being absolutely necessary for reasons of safety.

Standards for the Acceptance Or Rejection of Driven Rivets

Summary report of tests of improperly driven rivets and acceptability limits for such rivets, prepared under direction of the Advisory Committee for Engineering of West Coast Aircraft War Production Council, with chart giving recommended acceptability standards for all the common rivet malformations.

TESTS made by different organizations indicating that from the viewpoint of static and fatigue strength many types of imperfect rivets are satisfactory, came to the attention of the Advisory Committee for Engineering of the West Coast Aircraft War Production Council. Whereupon this committee established a project group to assemble representative existing test data, to supplement these data by additional tests where necessary and to prepare recommendations for the approval of the committee.

The purpose of the present report is to furnish quantitative criteria for the acceptance or rejection of rivets based on sound engineering considerations. The aim is not to encourage any laxity in production standards of workmanship that would result in an increased percentage of improperly driven rivets over that obtained at the present time, but to allow acceptance of a greater number of rivets that are malformed than is now permitted.

The primary, and somewhat surprising, point brought out by study of available data on the static and fatigue strength of rivets not conforming to nominal standards, is that the great majority of so-called defects do not decrease the strength below the "design" values for rivets, and certain of these defects actually improve the strength characteristics as compared to those of a normal rivet. An example is the cracked head rivet where overdriving work hardens the metal.

A second point, which is evident from the test report prepared by North American Aviation Corporation, is that if replacement rivets are the same size as the original rivets, the resultant strength of the riveted joint is less than the strength with the defective rivets. This is attributable to the greater slippage under load which prevents the replacement rivets from taking their proportionate share of the load, despite their being individually stronger than normal rivets. If the replaced rivets are larger than the original rivets this factor of slippage should be eliminated, but where edge distances are limiting or when skin gages are light the strength of the joint may be impaired. With light skin gages there is a tendency for the sheet to deform plastically during the riveting operation, especially if the rivets are driven hard or are large compared to the skin thickness.

Another factor of primary importance in determining, from a practical viewpoint, the acceptability of malformed rivets is that these normally constitute a small percentage of the total number of rivets in a given joint. Hence, even if the strength of such rivets were somewhat below normal, which is seldom the case, the decrease in strength of the joint as a whole would be negligible.

In light of present test information, the standards that have been generally employed by inspection in determining whether rivets shall be replaced have been unduly severe. Hitherto inspectors have not had quantitative criteria to aid them, nor test information available to assist them in forming a judgment. This situation has been in part recognized by the Services and some relaxation in regard to improperly driven rivets has been given officially.

The conclusions of four careful test reports follow. Complete reports are given in the general report prepared by the West Coast Aircraft War Production Council. The accompanying chart gives recommended acceptability standards for all the common rivet malformations. Essentially these standards are higher than permissible from considerations of structural strength as it is recognized that the limiting factor is general maintenance of proper workmanship standards in production. It was concluded, therefore, that a great saving in man-hours in the aggregate will result from the adoption of the recommended criteria for acceptability of improperly driven rivets

	Dimension Note: These limiting
Rivet size	Nominal Diameter 1.5 *d* — Height 0.5 *d*
	1
3/32	0.141 — 9/64 — 0.047 — 3/
1/8	0.188 — 3/16 — 0.063 — 1/
5/32	0.234 — 15/64 — 0.078 — 5/
3/16	0.281 — 9/32 — 0.094 — 3/
1/4	0.375 — 3/8 — 0.125 — 1/
5/16	0.469 — 15/32 — 0.156 — 5/
3/8	0.562 — 9/16 — 0.188 — 3/
Sketch of Limiting Defect	
Remarks	

by the government agencies and the inspection division of all aircraft companies, and that acceptance of these criteria will not result in any decrease in essential quality of the structure.

Conclusions given in Report PR-61, November 11, 1943, from North American Aviation, Inc., "The Use of Defective Rivets" by W. B. Jackson, are:

1. The accepted practice of replacing defective rivets is not considered necessary or practical.

2. The sample defective rivets were found to be satisfactory and are considered entirely suitable for use in production without replacement.

3. The defective rivets were found to be superior to the replacement rivets.

4. The replacement rivets showed a 17 percent average increase in deflection, at failure, over the defective rivets.

5. The replacement rivets showed a 33 percent average increase in deflection, at design load (allowable shear strength) over the defective rivets.

Conclusions given in P. T. Report No. 42-62, December 10, 1942, from Aluminum Research Laboratories of Aluminum Company of America, "The Effect of Diameter of Driven Head on the Static Strength of Single-Riveted Lap Joints in Thin Sheet," prepared jointly by R. H. Damon and E. C. Hartman, are:

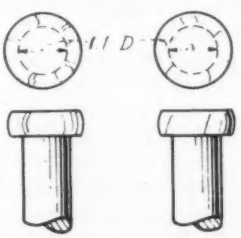
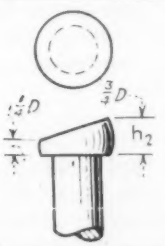
The following conclusions are based on the static test results described herein on single-riveted lap joints composed of various thicknesses of Alclad 24S-T sheet joined with $\frac{1}{8}$ in. 24S-T rivets.

1. There is a consistent increase in breaking load with increase in diameter of driven head regardless of whether the specimens fail by pulling the rivet head through the sheet, by tearing the sheet, or by shearing the rivet.

2. In these tests shear failures of the rivets were encountered consistently in

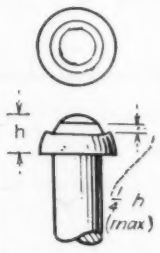
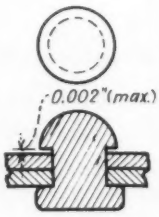
Acceptability Limits for Sub-Standard Quality Aluminum Alloy Aircraft Rivets

General Note: In judging the acceptability of improperly driven rivets, the general quality of the workmanship on an assembly should be taken into account. If this is good, then a more liberal interpretation of the criteria on this chart is recommended than if the general quality of the riveting is substandard.

Formed Head (dimensions are not applicable to tack rivets)				Cracked Heads						Cocked (Beveled) Head			
Minimum Diameter 1.3 d		Maximum Height $\frac{2}{3}$ d		Maximum Diameter $1\frac{2}{3}$ d		Minimum Height $\frac{1}{3}$ d		Maximum permissible length of crack $(D-1.1d)$ /2 or 0.062 maximum						Minimum h_1		Maximum h_2	
								Nominal D (1.5 d)		Minimum D (1.3 d)		Maximum D ($1\frac{2}{3}$ d)					
2				3				4						5			
0.122	1/8	0.062	1/16	0.157	5/32	0.031	1/32	0.019	1/64	0.007		0.027	1/32	0.023	1/32	0.070	1/16
0.163	5/32	0.083	5/64	0.208	13/64	0.042	3/64	0.025	1/32	0.010		0.036	1/32	0.031	1/32	0.094	3/32
0.203	13/64	0.104	7/64	0.260	17/64	0.052	1/16	0.031	1/32	0.012	1/64	0.044	3/64	0.039	3/64	0.117	1/8
0.245	1/4	0.125	1/8	0.312	5/16	0.063	1/16	0.037	1/32	0.014	1/64	0.052	3/64	0.047	3/64	0.141	9/64
0.325	21/64	0.167	11/64	0.416	13/32	0.083	3/32	0.050	3/64	0.019	1/64	0.062	1/16	0.063	1/16	0.188	3/16
0.406	13/32	0.208	13/64	0.520	33/64	0.104	1/8	0.062	1/16	0.023	1/32	0.062	1/16	0.078	5/64	0.235	15/64
0.487	31/64	0.250	1/4	0.625	5/8	0.125	1/8	0.062	1/16	0.028	1/32	0.062	1/16	0.094	3/32	0.281	9/32
																	
Rivets not conforming to above limitations may be restruck on #2 or shop head if head thickness permits.								The determining criteria should be the degree of penetration of cracks rather than their number. Acceptable cracks should be approximately radial, and two or more adjacent cracks should not intersect so as to form a potential cause for a portion of the head to chip off. Not more than three open cracks (as shown) are acceptable. Superficial intersecting cracks are not cause for rejection. It is recommended that the larger rivets, especially if driven hard, be bucked on the #1 head and driven on the #2 or shop head, using a conical or stepped set.						Mean height may not be less than $\frac{1}{3}$ d.			

Acceptability Limits for Sub-Standard Quality Aluminum Alloy Aircraft Rivets

(continued)

Concentric Stepped Head or Truncated Conical Head	Flatted Head	Offset Head	Concentric Ringed Head Permissible depth ¼ head height	Stepped Head	Incompletely Driven (Open) Head	Open Head (Tilted)	
6	7	8	9	10	11	12	13
							
For the #2 or shop head, this type is acceptable and recommended for 3/16 and larger rivets in order to reduce the tendency to crack.	It is permissible to use a flat set on the #1 or manufacturing head.	The head may be tangent to the shank. If the hole shows the rivet is unacceptable. Not acceptable in integral tank sections or pressure fuselages except if minor in degree.	This defect is produced by use of too small set. Acceptable only if occurrence is occasional. If diameter of ring is equal to or greater than minimum head diameter in Col. 2, its nature is immaterial.	Stepped part must not be less than permissible minimum head thickness. Unnecessary to chip or file high part.	Unacceptable if rivet is loose if 0.002 feeler gage can be inserted to shank. If 0.002 feeler gage can be inserted to shank rivet can be restruck. If gap less it is unnecessary to restrike. Open head rivets are not acceptable in integral tank sections or in pressure fuselages.		

rivets driven in 0.040 in. thick sheet. In thinner gages of sheet, failures of the joints were either by pulling the rivet heads through the sheet or by tearing the sheet out partially or completely ahead of the rivet.

3. In general, the type of failure encountered in any set of five identical specimens was consistent throughout the set. There was only one case in which at least four of the five specimens in any set did not show the same type of failure.

4. When the breaking loads in these tests are corrected for the difference between the actual properties of the rivets and sheets and the guaranteed minimum properties, the resulting reduced breaking loads are found to be higher than the present *ANC*-5 allowable values in all cases in which the driven head diameter is equal to or greater than 1.3 times the shank diameter. It seems clear, therefore, that under present methods of aircraft design satisfactory static strengths will be obtained for rivets having head diameters as small as 1.3 times the shank diameter.

Conclusions given in Report No. 12-43-9, April 29, 1943, from Aluminum Research Laboratories of Aluminum Company of America, "Effect of Cracks in Driven Heads on the Static and Fatigue Strength of 24S-T Rivets," by C. Wescoat, are:

The following conclusions are based on the static and fatigue tests described herein on ⅛ in. 24S-T rivets driven with various aging times and driving pressure so that some of the driven heads were cracked and others were uncracked:

1. The static tensile tests of the rivets driven in special steel tools show that rivets with cracked heads are about 2 percent stronger than those with uncracked heads. The average strength of the cracked head rivets was 70,100 lb. per sq. in. or about 13 percent greater than the value of 62,000 lb. per sq. in. specified for 24S-T rivet wire.

2. Static shear tests of the rivets driven in single lap joints in 0.064 in. thick 24S-T sheet show the rivets with cracked heads to be about 6 percent stronger than those with uncracked heads.

3. The average shear strength for the cracked rivet heads was 47,300 lb. per sq. in. which is 35 percent higher than the specified value of 35,000 lb. per sq. in. for 24S-T rivets. This difference would have been even greater, of course, had the shear strength been based on the nominal shank diameter of the rivets instead of on the hole diameter.

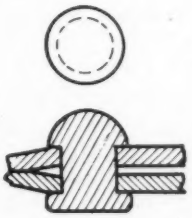
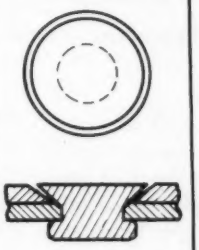
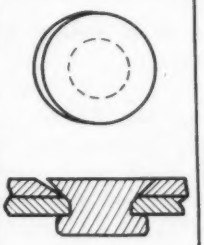
4. Shear fatigue tests on the rivets driven in single lap joints 0.064 in. thick 24S-T sheet show that there was no appreciable difference in fatigue strength between the rivets with cracked heads and those with uncracked heads. The fatigue curve for both sets of rivets appeared to justify a fatigue strength of 120 lb. per rivet at 100 million cycles of completely reversed shear stress.

5. The results of this investigation indicate that from the standpoint of structural strength under static and fatigue loading even severe cracking of driven heads of 24S-T rivets does not affect the proper functioning of the rivets.

Discussion and conclusions given in Report No. 3406, December 12, 1941, from Douglas Aircraft Company, "Fatigue Tests of Cracked 17S-T Rivets

Acceptability Limits for Sub-Standard Quality Aluminum Alloy Aircraft Rivets

(continued)

Swelled Rivet (Sheet buckled at rivet)		Open Countersink	Countersink Partially Open	Projecting Head Countersunk Rivet	Depressed Head Countersunk Rivets or Dimpled Rivets
Internal Gap	Open Gap				
13	14	15	16	17	18
					
Acceptable if gap is isolated.	Restrike if 0.003 feeler gage can be inserted to shank. If this does not correct, remove rivet and clean out chips. Gap at edge may not exceed 0.015. Open gap not acceptable in integral tanks or pressure fuselages.	This defect is unacceptable. If skin thickness permits, remove and recountersink for next larger size. If approved equipment is available for shaving, the #2 or shop head may be formed in the countersink and any projection shaved flush, if aerodynamic or interference considerations make this operation advisable.		Suitable maximum tolerances for high performance airplane are 0.002 on leading edge (10 percent of wing chord) and 0.004 elsewhere, specific tolerances depend on type of airplane and aerodynamic location.	Replace if head is more than 0.004 below surface. If machine countersunk and skin thickness permits replace with next larger size. No depression permissible in integral tank sections or on pressure fuselages. The #2 or shop head may be formed in the countersink in case of replacement rivet.

Driven in Hard Condition," by W. W. Bradley, are:

The test showed that the cracks apparently did not extend far enough to reach the stressed part of the rivet, and thus weaken it in fatigue. The work hardening caused by driving the rivets in the hard condition improved the fatigue properties of all but three (out of 14 sets) of the specimens. These three were joints in which the sheet was critical in bearing. It is probable that under such conditions the sheet may be reloaded enough during the driving of the rivet to lower its fatigue resistance slightly. However, all specimens lasted long enough to warrant their being considered satisfactory. (The average time before failure in the case of the slightly cracked specimens was 118 percent that of the uncracked specimens and the corresponding value in the case of the badly cracked specimens was 148 percent.)

Driving 17S-T aluminum alloy rivets in the hard condition to 1½ diameters upset is considered satisfactory, even though the upset ends may become badly cracked.

Spectrographic Iron 99.99 Percent Pure Produced in High Frequency Furnace

Iron that is 99.99 percent pure is being produced in high-frequency furnaces at the rate of 1,000 lb. per year by Westinghouse Electric & Manufacturing Company. The iron is used for spectrographic analysis of metals to determine their impurities.

Rods of the pure iron about the size of a pencil are heated by an electric arc in a spectrograph. This causes the iron to give off light rays which print a wavelength picture. Similar pictures of the metal being tested are compared with the iron wavelength picture, enabling swift and accurate determination of the composition of the specimen metal. Iron is used as a standard because its spectrographic picture contains a large number of lines, making identification of the test metal components easy.

Until the "mass-production" process was perfected by Dr. T. D. Yensen, manager of the magnetic department, the best standard obtainable was iron that was 99.9 percent pure. Dr. Yensen's process consists first of electrolysis and then heating the material from which the iron is derived in a high-frequency furnace with a hydrogen atmosphere.

In the electrolytic stage a bar of high-grade iron ore and a bar of lead are put in a solution of iron salts. An electric current breaks down the iron bar and deposits a spongy mass of nearly pure iron on the lead bar. This mass is removed from the lead bar and placed in a furnace through which hydrogen gas is pumped. A copper coil around the outside of the furnace carries the high-frequency current that melts the iron. Carbon and oxygen in the metal combine with the hydrogen gas and are removed, leaving the high-purity iron.

Cost of Parts Finished by Grinding Is Reduced by Correct Design

S. H. NEADY
Assistant Chief Engineer, Landis Tool Company

Production considerations and practice that should govern the design of ground cylindrical parts to obtain low cost. Original and redesigned parts are described to show how time-wasting operations can be eliminated and the performance and life of grinding wheels increased by correct design.

MILLIONS of man-hours are wasted in machine shops because many designers do not fully understand the production problems which are peculiar to grinding.

It is often forgotten that with all of its advantages as a method for securing accuracy of dimension, straightness, roundness, parallelism and concentricity, together with high surface quality, grinding is not an efficient way to remove large thicknesses of material.

For grinding from the rough casting or forging not more than $\frac{3}{32}$ in. should have to be removed by the wheel. It is not necessary for the wheel to get under scale as cutting tools must. A quarter as much stock as would be needed for a lathe tool will be enough for a cylindrical grinding operation. Yet it seems difficult for some designers to get away from the allowances they make for cutting tools when designing a part that is to be ground from the rough.

With the use of automatic grinders and automatic sizing methods it is also important that parts come to the grinder with a uniform amount of material to be removed. Wide variations require changes in set-up and manual manipulation instead of automatic grinding, entirely aside from the material wasted on the oversize pieces.

Because of the ability of grinding to do accurate work of fine surface quality, there is too often a tendency to be on the safe side and to specify closer tolerances and better surfaces than are needed. Both are time consuming, even when automatic sizing is used. It is wasteful to demand accuracy of a ten-thousandth when a thousandth would be satisfactory.

Since fine surfaces have to be carefully built up, there is considerable difference in the machine-time and man-hours required to grind a part with a surface quality of 3 microinches r.m.s. and one of 20 microinches r.m.s. One shop which has made a careful study of relative costs has found that it costs up to four times as much to medium grind as to rough grind, eight times as much to finish grind as to rough and ten times as much to do what they term "fine grinding" as to rough grind.

This seems conservative when it is considered that a rough grind involves but a single operation, often with a coarse grit wheel that removes material rapidly, while a fine surface may require several passes with each of as many as four wheels, some of them very fine grit.

These points are fundamental to all grinding. There are other points in the design of individual parts which call for the ability to visualize what the grinding operation on the part will involve. Take the question of how the work is to be driven. Fig. 1 shows a hollow cylindrical part as redesigned. Originally the part was designed with a short, steep chamfer at the edge of the drilled hole. As a result the part had to be dogged while one end was ground, removed from the machine, the dog attached to the ground end and the other end ground.

To eliminate the time wasting dogging and re-dogging, the part was redesigned with a long chamfer at the open end as shown in Fig. 1. This provides a long enough contact so that the part can be driven by a live center. Since this is a plunge-cut job, the grinding time is reduced and the time formerly spent adjusting and removing dogs and turning the piece end-for-end is eliminated. Obviously, this piece could have been effectively ground by the centerless method, but centerless machines were not available in the shop at the time this particular part went into production.

The part shown in Fig. 2(*A*) could not be centerless ground because of the four slots. This part had to be dogged twice, once at each end, since both lands had to be ground their full length. To avoid this, the part was redesigned as shown in Fig. 2(*B*) with a small diameter section projecting from the left end to which the dog could be attached so that the entire length could be ground by plunge-cut, with a wide-faced wheel. Incidentally, if a part must be ground on the face that is dogged, the economics of wide-wheel plunge-cut grinding cannot be obtained.

Although the projecting end for dogging must later be cut off, this method

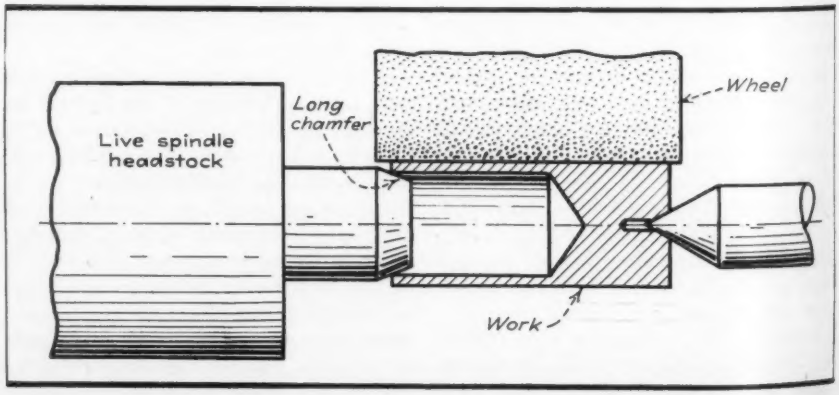


Fig. 1—Hollow cylindrical part with long chamfer at edge of drilled hole permits driving the part by a live center. Redesign also permits use of plunge-cut grinding.

reduced the entire set-up and grinding time by half. To re-dog a piece is essentially equivalent to grinding two pieces.

At the suggestion of the shop, a further improvement was made in the design of this piece. Since the factor of safety was ample, it was permissible to drill a hole in one end as shown in Fig. 2(*C*) to take a driving pin. This saved the material formerly wasted in the end projection and also the time required for cutting it off after grinding.

While some parts cannot with safety be weakened by drilled holes, they can often be used where the design permits in many parts that must be cylindrically ground.

The part shown in Fig. 3 is an example of the use of holes which resulted in notable savings. One common wrong design, from the production point of view, is making plain rings so that they must first be chucked for internal or face grinding and then put on an arbor for external cylindrical grinding between centers. At best this calls for two set-ups on a universal grinder. At worst, and too often, it means moving the part from an internal grinder or surface grinder to a plain cylindrical

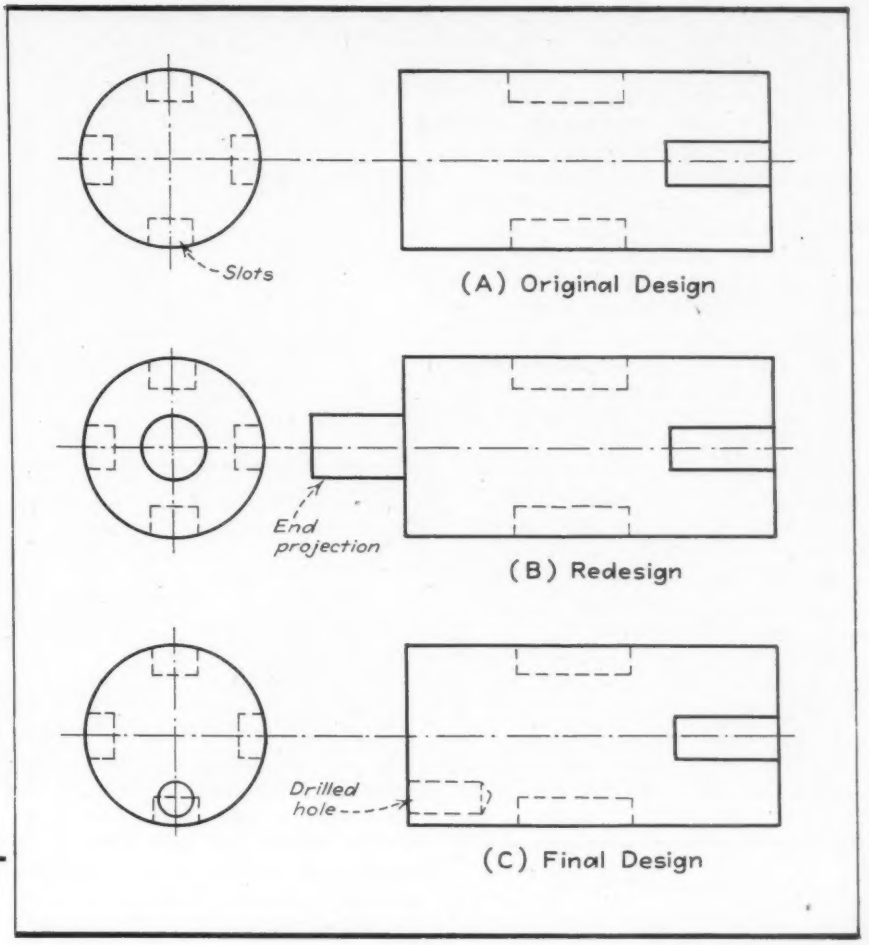


Fig. 2—(A) As originally designed the part could not be centerless ground because of the four slots. (B) Redesign of part provided an end projection to which a dog could be attached. (C) Final design had a drilled hole in one end to take a driving pin.

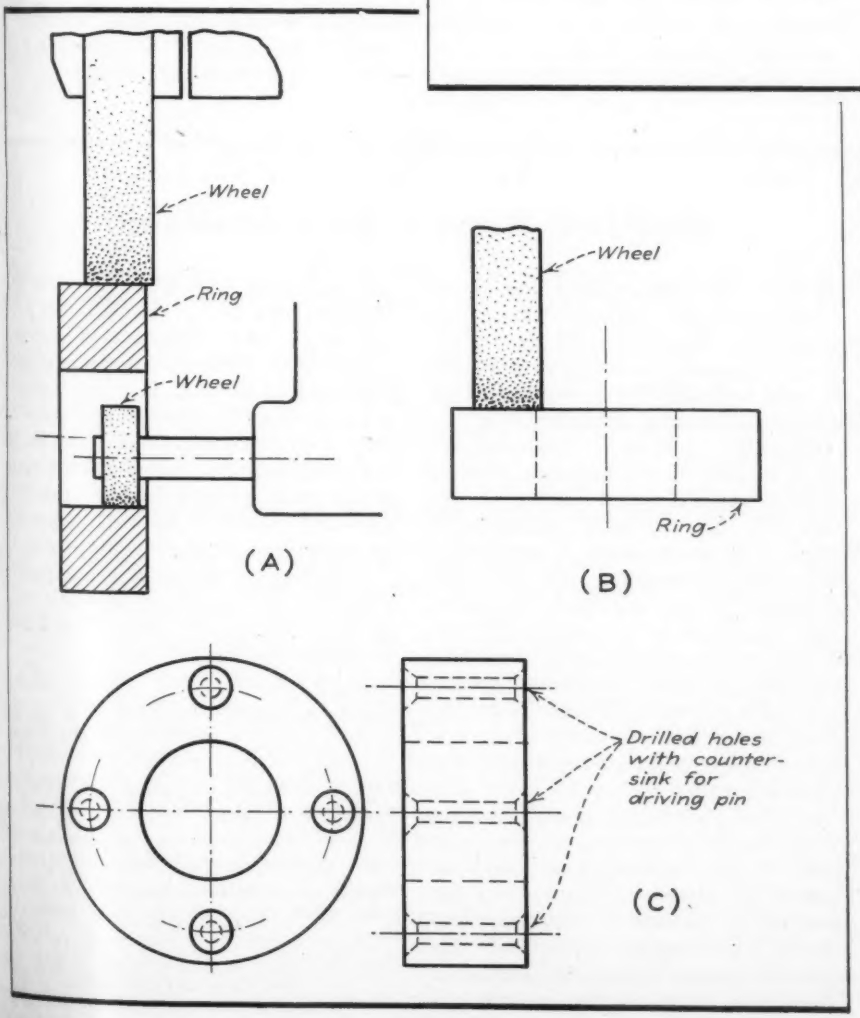


Fig. 3—(A) Grinding the outside and inside diameter of a plain ring. (B) Surface grinding one face of a plain ring. (C) Ring with drilled holes for pins.

machine. Two set-ups and the services of a truck and helper, a single set-up on a universal or a plain machine equipped with an internal grinding attachment would oftentimes be all that is required.

Here again, it is necessary that the design or use of the ring will not be affected by four drilled holes, shown in Fig. 3(*C*), by means of which the ring can be attached to a T-slot face plate. If both sides of the ring are to be surface ground, the holes must be countersunk at both ends, and one change in set-up will be needed to reverse the faces.

It is unusual for a piece such as a pulley to be designed with obstructions which prevent a grinding wheel from reaching the part marked "grind," but

often a part is so designed that to reach the specified surface a very small wheel must be used.

Small wheels have several disadvantages. They wear rapidly and require frequent dressing and truing, which increases wheel cost and down-time for changing wheels. Also, they require high spindle speeds, often higher than are available on the machine, to give correct peripheral speed of wheel. Low surface speeds, of course, retard production.

The hub of the part shown in Fig. 4 was originally so large that only a 1½-in. diameter grinding wheel could get into the rim space. When faced by the shop with low production figures and high costs, the design staff decided that the hub could be considerably smaller, so much smaller that a 12-in. wheel is now used. With this change the production rate is up where it should be and costs are notably reduced.

Parts can often be redesigned so that a cylindrical portion is much shorter than before, thus making it possible to avoid time-consuming traverse grinding by substituting plunge-cut with widest

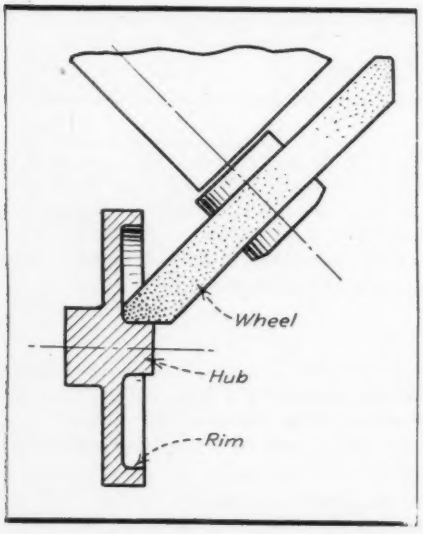


Fig. 4—Set-up for grinding a hub extension on part that has a flange or rim.

wheel the available machine will take.

It is especially desirable to avoid traverse grinding of parts which have a shoulder, since the wheel then must usually be carefully fed by hand when it approaches the shoulder. Also, because the wheel cannot pass off the work it wears unevenly, the leading edge does all of the work and breaks down excessively. This makes the securing of a proper corner where shoulder meets diameter all but impossible. Therefore, it is well to design a piece with a shoulder short enough so that the diameter can be plunge-cut, which gives not only fast production but a fine surface on both diameter and face.

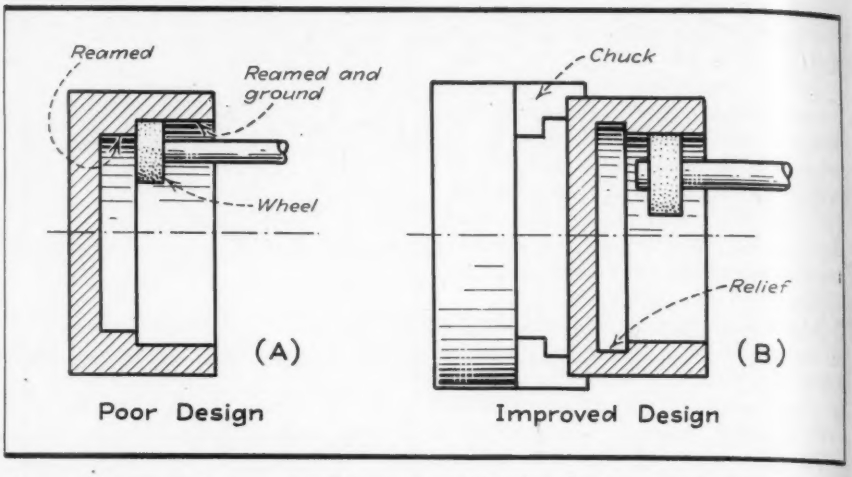


Fig. 5—(A) Wheel leaves a shoulder against which the wheel will bump on succeeding passes. (B) A relief at the bottom of hole will permit the wheel to run over edge.

If the piece cannot be shortened enough for plunge-cut grinding, study the design to see whether the troublesome shoulder cannot be entirely eliminated, often it can be.

It is often required that a hole be internally ground for only part of its length. This usually slows production and nearly always results in needlessly fast wheel wear. Even if the operation preceding grinding is to ream the hole to its full depth, the first pass of the wheel part way through the hole will leave a shoulder which, minute though it is, provides an obstacle against which the wheel will bump on succeeding passes as shown in Fig. 5(*A*). Since wheels are not designed to withstand such sudden stresses, wheel after wheel will be ruined, with resulting high wheel cost and slowed production. Turning a relief at the bottom of the hole as in Fig. 5(*B*) will prevent the trouble.

Modified Buna-S Now Available

A NEW SYNTHETIC RUBBER latex electrical insulation called Nubun, developed by United States Rubber Company will permit the design of new types of wire and cable with improved electrical and physical characteristics.

Qualities of Nubun insulation include flexibility, and impermeability to water. It is available in laminated construction. The synthetic insulation is said to be exceptionally homogeneous following vulcanization and has high dielectric strength and insulation values. The compound is low in specific conductive capacity, has good aging qualities because of the presence of special anti-oxidants, and will resist wear because by the nature of the latex process, the rubber particles are not distorted or broken down by milling.

In developing Nubun it was necessary to modify and improve upon the basic buna S polymer before it could be applied to wire in the latex form and produce an acceptable insulating material. These improvements took the form of changes in the composition of the basic polymer, the process of polymerization and other fundamental modifications. The standard GR-S rubber found most advantageous for the greater part of the Government's program and for most military applications is based on a 75 percent butadiene—25 percent styrene composition. The modified polymer has a special styrene ratio and is prepared by a modified reaction technique which gives it improved processing and insulating properties.

According to the rubber company's engineers, the following electrical and physical values have been established by laboratory test:

PHYSICAL TESTS	BEFORE AGING
Tensile Strength	2,500 lb. per sq. in.
	After 96 Hr. Aging In Oxygen Bomb
Tensile Strength	2,000 lb. per sq. in.

ELECTRICAL TESTS

Voltage breakdown after submersion in water at room temperature 650 volts/mil

Insulation resistance constant K after submersion in water at room temperature. 54,000

Specific Inductive Capacity at 70 deg. C.
(A) After one day in water.....3.0
(B) After three days in water...3.2

American Metal Products Co.

Nosing ½ in. diameter tubing on small swaging machine.

Tubes With Reduced Ends For Light Tubular Structures

ARTHUR Z. BENDAR
Production Design Engineer, Lockheed Aircraft Corporation

Improved methods of reducing the diameter of round tube ends permit more efficient applications of tubing to structural subassemblies. Proper design is illustrated and common reducing and swaging methods are compared.

COLUMN strength and section properties of tubes of a given weight increase with the diameter up to the point where local crippling takes place. Hence a thin-walled tube makes a stronger column than a tube of equal weight but of smaller diameter and thicker wall. This is attributed primarily to the greater slenderness ratio of a column of smaller diameter. On the other hand, larger tube ends require larger fittings which add weight to the structure, require more space, and add to the difficulty and expense of making strong joints either by welding or bolting. Small diameter heavy-wall tubes are usually more suitable for making end connections and joints in a tubular structure. To overcome this disadvantage of the large diameter thin-walled tubes, the ends are reduced to a smaller diameter and heavier wall. Reduction of the tube end diameter reduces the sizes of fittings materially, thereby overcoming the disadvantages of large tubes that are mentioned above.

Recent developments in methods of reducing round tube ends give closer tolerances, especially on angularity. This has permitted a more extensive use of tubing, particularly in aircraft structures. Landing-gear braces, torque tubes, and control tubes are typical applications.

The three methods for tapering the ends of tubes are shown in Fig. 1. Increase in wall thickness of the reduced portion of the tube can be controlled more readily when the pressure-roll

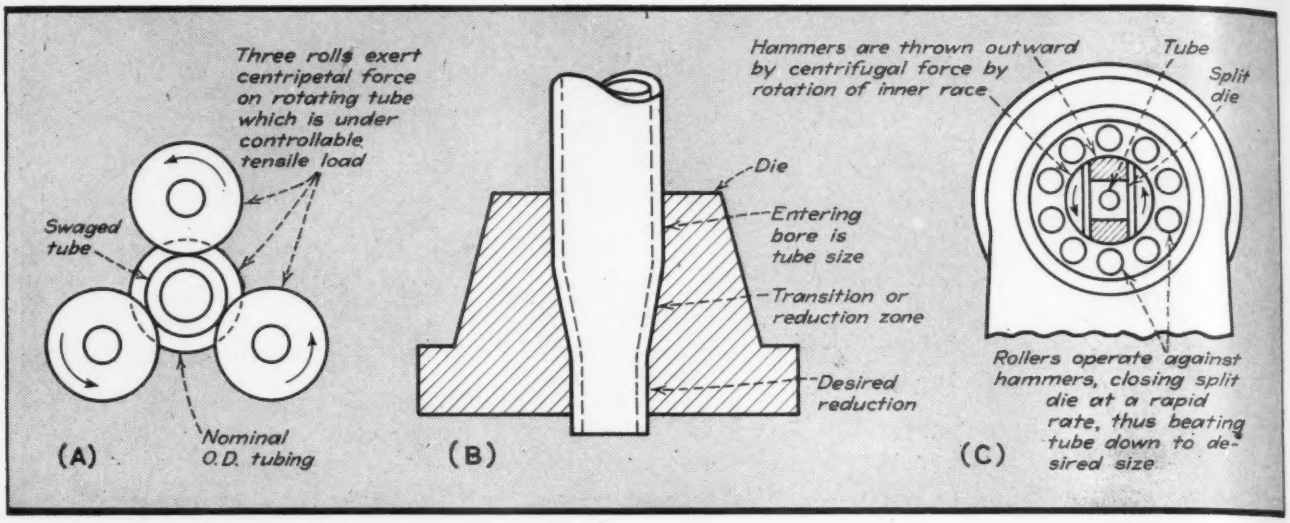

Three rolls exert centripetal force on rotating tube which is under controllable tensile load
Swaged tube
Nominal O.D. tubing
(A)
Die
Entering bore is tube size
Transition or reduction zone
Desired reduction
(B)
Hammers are thrown outward by centrifugal force by rotation of inner race
Tube
Split die
Rollers operate against hammers, closing split die at a rapid rate, thus beating tube down to desired size
(C)

Fig. 1—(A) Pressure-roll method of reducing tube diameters. (B) Push-through sizing die is the simplest method of reducing tube ends. Tube end should be chamfered and have an allowance for trimming. (C) Impact swaging machine. Tube holding mechanism must be rigid, concentric with die holder, and must rotate the tube. Wall thickness can be controlled by mandrels.

method, (*A*), is used than when the push-through die or impact swaging machine methods, (*B*) and (*C*), are used. Ordinarily when either of the last two methods is used and it is necessary to obtain a definite wall thickness, as for flashweld applications, samples of the tube must be reduced and measured. A mandrel can be used inside the tube for controlling wall thickness but it adds materially to the cost because reducing operations are slower and mandrels require upkeep.

Dimension Control

Amount of eccentricity and degree of angularity, illustrated in Fig. 2, depend to a considerable extent on the condition of the machines on which the reduction is made. The maximum possible total eccentricity of centers, which will be the accumulated tolerances of both concentricity and angularity—doubled if both ends are reduced—may be high and must always be considered. The illustrated pressure-roll method of reducing tube diameter has given excellent results with respect to concentricity.

Push-through dies require a technique that takes time to acquire. A concentricity of diameters and parallel axes within plus or minus 0.005 in. has been maintained by Summerill Tubing Company using the push-through die method. Thousands of tubes of different sizes and wall thicknesses are reported to have been produced within this tolerance. This tolerance is closer than Summerill obtains by roll spinning in the Dewey-type machine without additional operations of straightening and checking after forming.

The Dewey roll-spinning method has numerous features, however, particularly

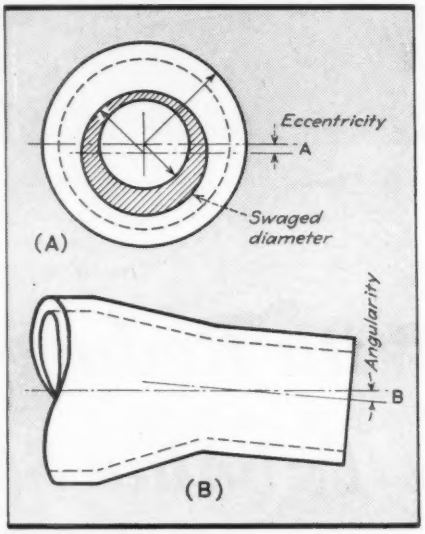


Fig. 2—(A) Showing how eccentricity of reduced tube ends is dimensioned. (B) Showing how angularity of reduced tube ends is dimensioned. Table I gives dimensional tolerances now obtained on three materials by the three methods.

adaptable to tubes having wall thicknesses of 0.095 in. and thinner and lengths up to 20 ft. Wall thickness in the reduced section usually can be made greater, equal or less than that of the base tube. Difficulties in maintaining tolerances have been experienced with tubes having walls as heavy as $\frac{1}{8}$ in. because the slightest surface imperfections, such as variation in temper, make it difficult to obtain uniformity. Still greater possibilities in the application of this method are believed possible by improvement in design of the machine and by maintaining equipment in better condition.

The method of pushing into the die has been developed in the last two years for application to alloy steels. Special effort has been made to develop proper die shapes for pushing in order to minimize column failure, to eliminate straightening after the pushing operation and even to eliminate trimming of the ends after forming some parts. In some instances two reductions have been made without intermediate anneals.

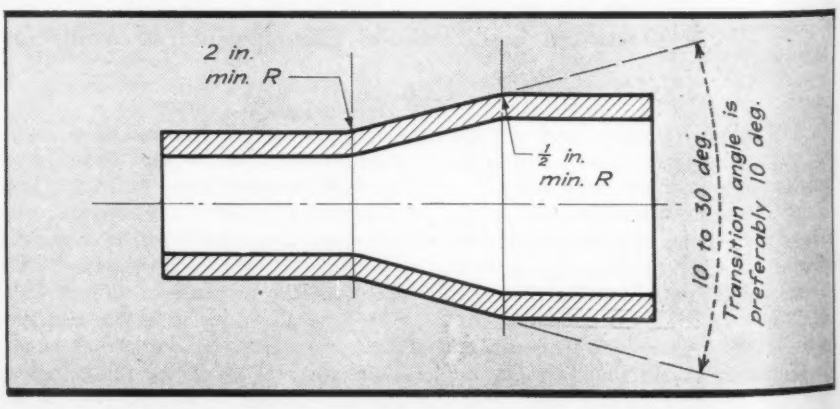


Fig. 3—Dimensional limits for design of reduced tube ends. Wall thickness of the reduced end, as indicated by Table I, depends greatly on the material.

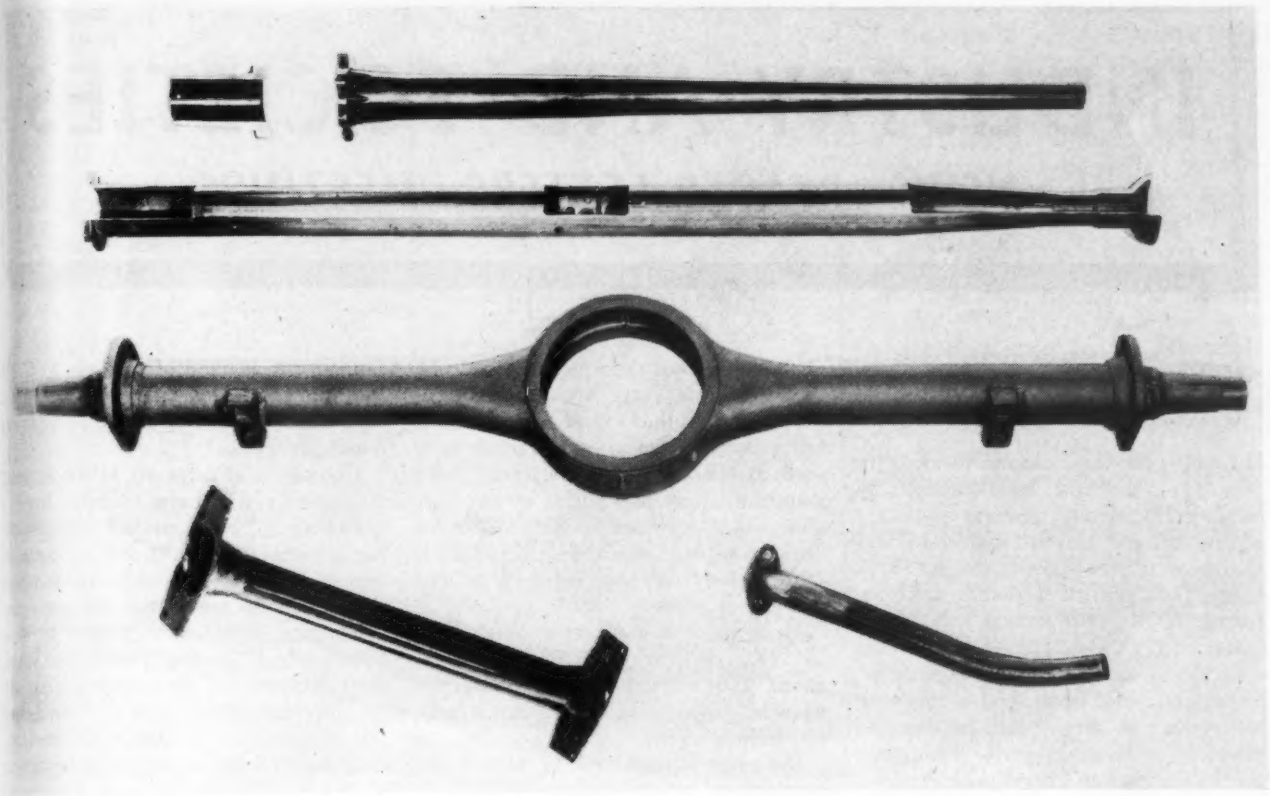


Fig. 4—Automotive and truck applications of swaged tubing, showing passenger and truck torque tubes, truck rear axle housing and two small automotive parts.

Table I—Dimensional Tolerances For Reduced Tube Ends

Method	Material	Maximum Eccentricity	Maximum Angularity	Wall Thickness
Push-Through Sizing Die	Aluminum	±0.005	1/2 deg.	Increase is Variable.
	Low carbon	±0.010	1/2 deg.	
	Alloy steel	±0.010	1/2 deg.	
Impact Swaging	Aluminum	±0.010	1/2 deg.	Same as for No. 1.
	Low carbon	±0.010	1/2 deg.	
	Alloy steel	±0.010	1/2 deg.	
Pressure Roll	Aluminum	±0.005		
	Low carbon	±0.005	Negligible	Limited controlled increase and decrease dependent on cross-sectional area and degree of reduction.
	Alloy steel	±0.005		

O. D. tolerances on all three methods are within the plus or minus 0.010 in. of the manufactured tube tolerance, although No. 3 method requires plus or minus 0.020 for X4130 tubing only.

Pressures are being used that are theoretically beyond those for column failure.

Hot Swaging

Heavy wall tubes must be reduced hot by swaging or push-through dies. Tubes having a wall thickness of at least 0.375 in. have been swaged satisfactorily on the ends. Lengths of such tubes normally range from 1 to 5 ft. but longer tubes can be produced. In hot work there is no limit to the amount of reduction of tube diameter or to the ratio of tube diameter to wall thickness. However, since hot working leaves a poor surface finish, it should be used only when extreme reductions are required or when the swaged surface must be machined to a dimensional accuracy not obtainable by swaging or the ends are to be threaded. Usually a better surface is required than hot swaging produces.

In hot work it is important to guard against decarburization. Chrome moly steels decarburize rapidly at temperatures suitable for hot swaging. This would be particularly serious in parts to be heat-treated.

Light and average weight tubes are normally reduced cold. In cold working, the ductility of the metal and its work hardening properties determine the maximum amount of reduction obtainable. Tubes of X4130 steel and having a ratio of diameter to wall thickness as high as 30 to 1 can be reduced to ⅔ their original diameter at a reasonable cost. Low and medium carbon steel tubes can be reduced to 60 percent of their original diameter. Outside diameters usually range up to 4 in. but larger tubing can be reduced similarly.

Proper design for reduced tube ends is shown in Fig. 3. Commercial tolerances are given in Table I for tubes reduced by any one of the three methods mentioned.

The need and advantages of tubes with reduced ends for tubular members and structures has resulted in extensive technical developments that have also improved the manufacture of tapered, formed, and upset tubing. Ways have been devised for producing such modified tubing in greater ranges of shapes and sizes. Size limitations are largely a matter of fabricating equipment. While production costs are increased by these operations, the advantages gained often more than offset additional costs and are worth considering when designing tubular parts or structures.

INDUSTRY AND SOCIETIES

NEWS • READER LETTERS • MEETINGS

Slichter Describes Postwar Outlook

HOW BUSINESS AND LABOR are likely to fare after the war was outlined by Sumner H. Slichter, Lamont professor of economics at Howard University and chairman of the Committee for Economic Development Research Advisory Board, at the 1944 annual meeting of C.E.D.

So far as automobiles are concerned, he indicated that by the end of this year the number in service will be down to about 24 million. If employment after the war is higher than it was in 1940, Americans will probably wish to drive as high as 34 million automobiles. Thus, there might be an expected demand for 10 million automobiles when production of them is resumed. This does not include the demand for automobiles to replace those that have worn out.

By the end of the war there may be an assumed demand for the number of units indicated in the following list of items:

Vacuum Cleaners	3.5 million
Clocks	7.2 million
Radio Receivers	23.0 million
Refrigerators	5.2 million
Washing Machines	3.1 million
Waffle Irons	1.5 million
Heating Pads	1.8 million
Percolators	3.7 million
Toasters	4.5 million

Also, by the end of 1944 there will be a deficiency of at least 750,000 in the number of permanent dwelling units constructed since Pearl Harbor. A high percentage of the 6.6 million couples who have married in the past four years have not set up housekeeping, indicating that the accumulated need for household goods after the war will reach new highs.

Professor Slichter estimated that after the war 57 million people working 7.5 fewer hours per week than they are now and at 1943 prices and present efficiency would turn out about $156 billion of goods and services a year. The government will use about $31 billion of this product, leaving $125 billion of output available for consumption by individuals, business concerns and foreign customers.

The income of these people would be $130 billion a year. After payment of personal taxes they would have left $118 billion to spend on consumer goods or to save. Based on past experience, these people will buy $88 billion of non-durable goods and nearly $12 billion of durable goods. To this must be added a "catching-up" demand of $4.4 billion of durable goods.

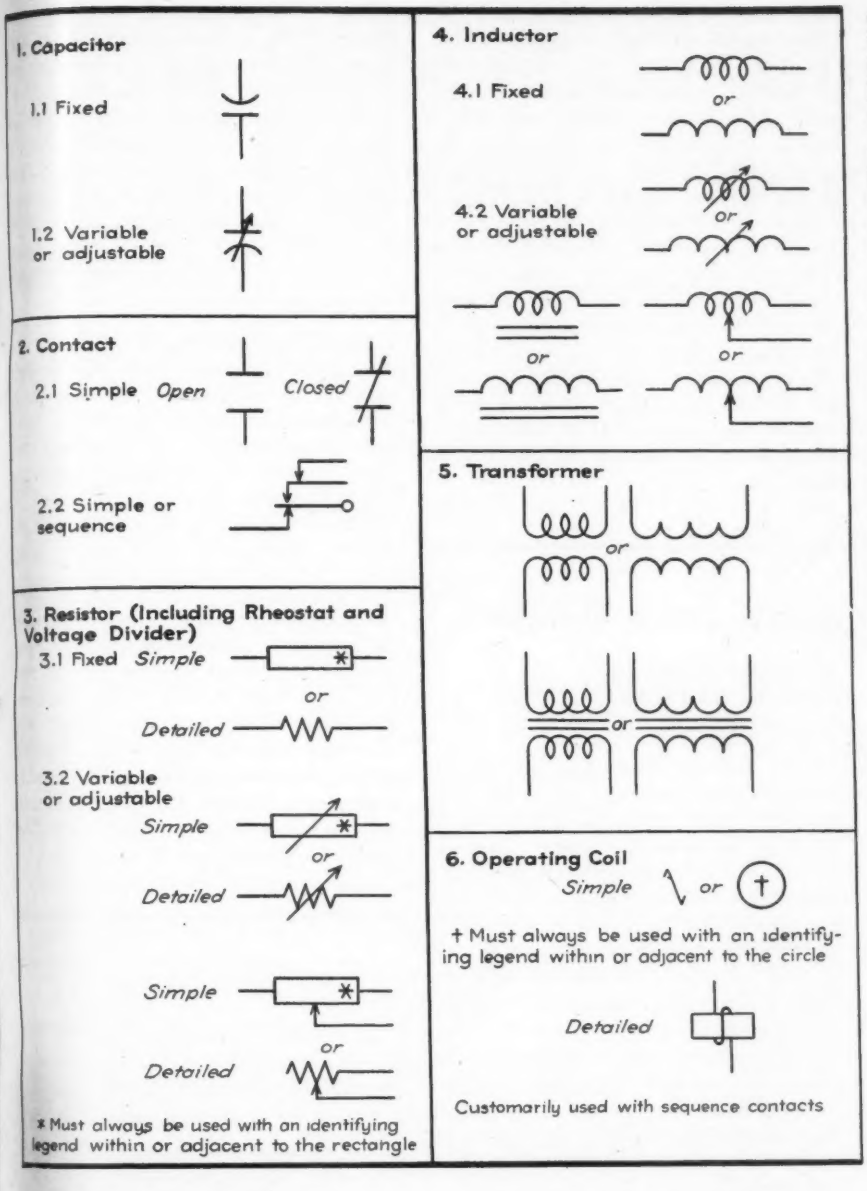
If no more houses are built than in 1939 the cost, at 1943 prices, will be about $2.6 billion; but eventually the demand for housing should run nearly $10 billion a year.

Business demands will be very large. Restoration of inventories will take about $3 billion for nearly three years. Plant and equipment will have a value of $16 billion. Exports will exceed imports by at least $3 billion. All of this indicates a demand of at least $1.5 billion more than the estimated output of 57 million people working 7.5 fewer hours per week.

Eventually, Professor Slichter said, the country will have to shift from a "catching-up" economy to a self-sustaining economy. This shift will, in some respects, be more difficult than the first shift from war production to peacetime production. Business will have to do a better job of getting people to spend their incomes for consumer goods and the government will have to do a better job of providing a hospitable environment for enterprise and of encouraging pioneering, innovation and expansion. Among the reforms needed in government policies by that time will be a thorough overhauling of the present system of taxation.

Radio Parts Electroplated on "Merry-Go-Round"

Automatic electroplating of parts used in radios, direction finders and other devices is done on this rotating machine by the Radio Division of Bendix Aviation Corporation. Tanks for various steps in the plating process are placed in a circle. Parts are placed on the hooks, as shown above, and the machine started. At proper intervals the parts are automatically lowered into and raised out of the tanks until they complete the circuit, when they are removed and replaced with other parts to be plated. One advantage is minimum handling of the parts. The only additional operation necessary is buffing.



Electrical Graphical Symbols Coordinated

BECAUSE of the confusion resulting from different groups using the same electrical symbols to denote different things the American Standards Association has developed American War Standard 232.11—1944, Coordination of Electrical Graphical Symbols. The recommended symbols for use on electrical diagrams are shown above. The following notes apply:

Capacitor—Where it is necessary to identify the capacitor electrodes the curved element shall represent the outside electrode in fixed paper-dielectric and ceramic-dielectric capacitors, the negative electrode in electrolytic capacitors and the movable element in variable and adjustable capacitors. When it is desired especially to distinguish trimmer capacitors the letter "T" should appear adjacent to the symbol.

Contact, Simple—The line representing contacts shall be approximately equal to 1¼ times the width of the gap between the lines.

Contact, Simple or Sequence—The symbol for sequence contact can also be used for a simple contact in order to maintain uniformity and avoid confusion on drawings.

Inductor or Transformer—When it is desired especially to distinguish magnetic core conductors or transformers a line or lines parallel to the axis of the loops should be used, as shown .

First Aluminum Alloy Freight Cars Ordered

HONORS for placing the first order for aluminum alloy freight cars of the conventional type to be used in general-purpose service go to Missouri-Pacific Railroad which recently ordered 25 aluminum alloy riveted hopper cars of 70-ton capacity from American Car & Foundry Company. While many cars have been built of lightweight metals in the past, they were for experimental purposes and for special services. This order, therefore, is the first to be placed by a railroad convinced of the practicability of the use of lightweight metals in car building.

The new design is the result of collaboration on the part of Missouri Pacific, Aluminum Company and A.C.F. engineers. Aluminum alloy will be used for the body while the center sill and bolster will be steel. The cars will each have an empty weight of about 38,000 lb. compared with an average 50,000 lb. for conventional all-steel 70-ton hopper cars. They will be 39 in. longer than the all-steel units, permitting a capacity increase of 240 cu. ft. The aluminum sheets are to be somewhat thicker than the conventional steel to give them equal strength.

Reconversion Courses Offered by Cooper Union

ENGINEERS now employed in war industries will be given an opportunity during the coming year to fit themselves for new types of work under the reconversion program by the Cooper Union School of Engineering in New York. Qualified workers will be admitted to advanced evening courses without charge, except for small laboratory fees, and without the formality of entrance examinations. The plan is designed not only to help war workers prepare for the reconversion program but also to provide additional training for men seeking promotion in war industries.

Although applicants admitted under the plan will not be candidates for degrees, and will be known as "special wartime participants," they will receive full academic credit for subjects taken and will be able to use that credit if they decide later to seek degrees. Each applicant must indicate how he expects to profit by the subjects he elects and must show that he is qualified to study those subjects by having completed the prerequisite courses in an accredited engineering college. Applications for the courses will be received until September 8, and the courses will open October 2. Among the subjects offered under the plan are:

Chemical Engineering—Unit operations; chemical engineering thermodynamics; fluid dynamics; physical chemistry.

Electrical Engineering — Advanced electrical machines; communications principles; advanced electric circuits; electrical engineering for other than

regular electrical engineering students.

Mechanical Engineering—Advanced heat power; internal combustion engines; engineering economy; mechanical engineering for other than mechanical engineering students.

Two Electric Iron Models To Be Sold by G.E.

UNDER recent OPA and WPB rulings and directive orders two models of electric irons will be manufactured by General Electric Company in its Ontario, Calif., plant. Both models will be of the automatic type. The majority of the 421,000 irons, the quota granted G. E., will retail at $8.55, including tax. The other model will sell for $5.70, including tax. These prices are comparable to those of prewar models. Both models will be of prewar quality and will be similar to the prewar irons manufactured by G. E. with only modifications in the external finish.

Delivery of the irons is expected to begin in September. Regular distributors will receive the first shipment and retailers will be able to offer the irons for sale to the general public shortly afterward. Quotas have been established for each geographical area within the United States based on the distribution of iron sales of 1940, adjusted to compensate for population shifts since that year.

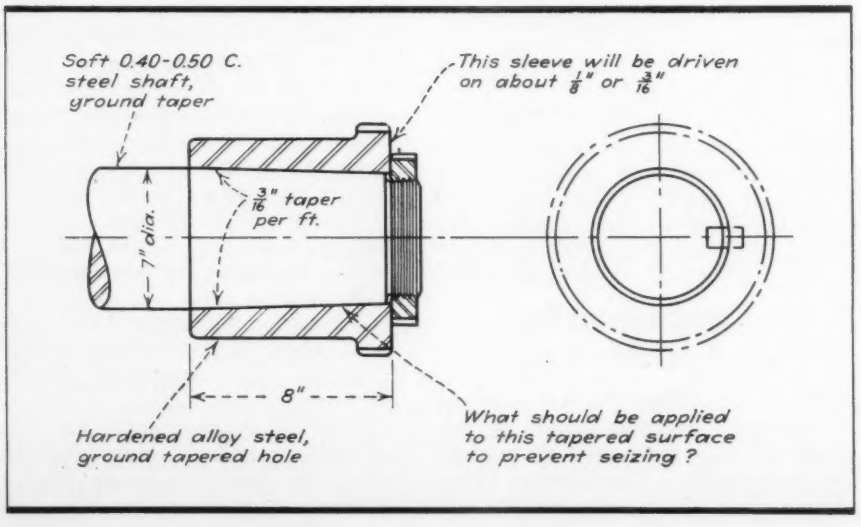
Discussions and Comments from Readers

ANTI-SEIZING COMPOUND SOUGHT BY READER

To the Editor:

The accompanying sketch shows the proposed design of a tapered shaft and a tapered bushing. These parts fit together tightly as a unit but must be taken apart on occasion. If the parts are properly assembled there will be some seizing of the metals and considerable difficulty will be met when the unit is disassembled. Do you know of any anti-seizing compound that can be applied to the surfaces before assembly that will eliminate seizing and prevent injury to the parts? —C. S. FORD

EDITOR'S NOTE—If readers who know of a suitable anti-seizing compound for this application will communicate this information to the editor it will be forwarded to Mr. Ford and later published in PRODUCT ENGINEERING for the benefit of other readers.


Soft 0.40-0.50 C. steel shaft, ground taper
This sleeve will be driven on about 1/8" or 3/16"
3/16" taper per ft.
7" dia.
8"
Hardened alloy steel, ground tapered hole
What should be applied to this tapered surface to prevent seizing?

READERS COMMENT ON JULY EDITORIAL

To the Editor:

Your editorial in the July number on PRODUCT ENGINEERING, page 465, was timely as were your other comments in previous issues on the patent situation. Personally, I agree with all you have said and I believe that few others can disagree in that the S.W.P.C. has fallen far short of its original objectives. To me this suggests a bright future for its child, the S.B.C., in the matter of a few "skylark feathers."

It seems to me that in addition to the various flaws that you point out in your editorial there would be an overlapping of responsibilities or duties between this proposed government bureau and the C.E.D.

Other than what I have read in the various periodicals, I am not very familiar with the activities of the C.E.D. nor of its operation in this area, but there is no question in my mind but that C.E.D. is designed to eliminate any need for such a government bureau.

Consequently, I feel that it would be a good idea for the engineering societies to take up this subject. Apparently, the senator who authored S-1913 felt that "there ought to be a law," and no doubt the various societies could bring him up to date on that point.

—EDWARD PRINGLE

To the Editor:

Referring to your editorial in the July, 1944, number, page 465, we are exceedingly interested in further information concerning the Small Business Corporation. If the agency has been established we would appreciate knowing where it can be contacted. If you have any information regarding the policies this also would be a great help. —T. N. LINDQUIST

EDITOR'S NOTE—The Small Business Corporation is the proposed new name of the government agency that is now called the Smaller War Plants Corporation. The change in name along with increased authority and scope of activities is embodied in bill S.1913 now in committee. Further information can be obtained from Smaller War Plants Corporation, Washington, D. C.

Meetings

American Association for the Advancement of Science—Annual meeting, Sept. 11-16, Cleveland, Ohio.

Society of Automotive Engineers—National tractor meeting, Sept. 13-15, Hotel Schroeder, Milwaukee, Wis.

Association of Iron & Steel Engineers—Annual meeting, Sept. 25-27, Pittsburgh, Pa.

American Society of Mechanical Engineers—Fall meeting, Oct. 2-4, Cincinnati, Ohio.

National Safety Council—National safety congress, Oct. 3-5, Hotels Sherman and LaSalle, Chicago, Ill.

National Electronics Conference—Oct. 5-7, Medinah Club of Chicago, Chicago, Ill.

Society of Automotive Engineers—National aircraft engineering and production meeting, Oct. 5-7, Hotel Biltmore, Los Angeles, Calif.

American Society for Metals—National metal congress, week of Oct. 16, Public Hall, Cleveland, Ohio.

Society for Experimental Stress Analysis—Annual meeting, Oct. 17-20, Hotel Carter, Cleveland, Ohio.

The *Stake* of the United States in Expanding World Trade

WITH the war in Europe racing to a climax, and with a sure pattern for the defeat of Japan already outlined, American business is confronted with the need for an immediate decision on long-term economic policy.

What is this country's foreign trade program to be after the war?

No intelligent appraisal of all the factors any longer can allow us to postpone considering the issue merely because, in the past, foreign trade absorbed barely eight per cent of our production.

Actually, a whole new set of conditions was injected into the picture by the first World War; but we persisted in ignoring these new factors.

Almost overnight, the United States was transformed from the largest debtor nation in the world to the second largest creditor nation. At the same time, we made faster technological progress than any other nation. Thus we created the need for more dollar exchange on the part of the rest of the world and simultaneously made it harder for other nations to earn dollars.

Today, as another, far vaster war is approaching its end, those changed circumstances are magnified. America has new responsibilities—to itself, and to the world.

Our war-inflated industrial capacity cannot be allowed to drop back to prewar levels without causing a domestic crisis which we dare not permit.

And, because so much of the world is geared to the American industrial machine, we can no longer contemplate calmly the repercussions of a largely self-sufficient trade program or of an unplanned foreign trade program. Either would inevitably set the stage for the next world war.

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If we are going to prepare ourselves intelligently to cope with this new problem, we must acknowledge certain basic principles.

World trade cannot be rebuilt simply by attempting to restore *prewar* flows of goods. The war has so completely changed the economic fiber of many countries that it is necessary to develop *new* trade relationships. The East Indies, for example, may find the demand for their rubber considerably reduced; the United States may, to a large extent, have to cease exporting cotton; Japan will need to find new substitutes for much of its exports of silk; the British will need new markets to replace the income which they formerly derived from their large overseas investments.

We cannot expand markets for our goods, at home or abroad, unless we find ways of buying more supplies from more people at home or abroad, so that they will have more dollars to spend.

And we probably cannot create increasing buying power abroad without first exporting more of our technical skills—our engineers, our production and management men—to build new markets for our own specialties.

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What is needed to rebuild the world's economic system?

1. Most basic of all, of course, are stable governments which command popular support. In the absence of strong governments, currency stability cannot be achieved.

2. Most war-stricken countries, for a year or two, will need rehabilitation loans, because they will require far more raw materials, equipment, and live stock than they can pay for out of current production.

3. Loans, however, are only a stop-gap, though often a necessary one. Far more important than rehabilitation loans will be the creation of better opportunities for war-stricken countries to sell to the rest of the world, particularly to the United States, South America, South Africa, and India. The ravages of war do not completely destroy the ability of a country to sell. Indeed, it is surprising what large supplies of certain commodities war-torn countries have on hand even before devastated industries have been restored. The invading troops in Normandy found shoes almost non-existent, but they found food more plentiful than in Britain.

   Better opportunities for war-stricken countries to sell would create opportunities for them to buy the things they will require to restore scattered industries and depleted farms, and would help those countries to get rid of the exchange controls which are now universal. So long as a country is able to expand its exports only slowly and painfully, and is dependent upon foreign loans to prevent the depreciation of its currency, so long will it carefully preserve exchange controls and other restrictions in imports. That is why large advances, either through an International Monetary Fund or an International Investment Bank, can make only limited contribution to the removal of trade restrictions.

4. Permanent monetary and credit arrangements are needed to protect nations against temporary pressure upon their currencies, to permit necessary changes in exchange rates to be made in an orderly manner, and to assure that governments never again will repeat the "beggar-my-neighbor" policies of 1931 and 1932.

5. Finally, the world needs a reversal of the trend toward economic self-sufficiency, which received a strong impetus from the first World War and an even stronger one from the great depression of the Thirties. This does not mean that the efforts of many raw-material producing countries to diversify their industries should be opposed. During the late Nineteenth Century and the first part of

this century, the international specialization of production was carried too far, with the result that many countries became dependent for a large part of their standard of living upon the export of one or two raw materials—coffee, sugar, rubber, silk, wheat, wool, and meat. Between the two World Wars, however, the pendulum swung much too far in the direction of self-sufficiency. Some densely populated industrial countries of Europe (Italy, France, and Germany) even attempted to become self-sufficient in wheat, fats, and sugar. So limited are the natural resources and technical skills of most countries that each one finds many things which it can produce only at prohibitive costs. Between the extreme specialization of the late Nineteenth Century and the more recent trend toward extreme self-sufficiency, a happy medium should be sought.

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What role should the United States play in reconstructing the world's international economic system?

There are those who suggest that the United States be a more or less permanent Santa Claus. They believe that an excess of exports could be financed only by "loans"—loans that would eventually turn into gifts, after producing bitter controversy over why the "debtor" country did not meet its obligations. The persons who assert that full employment can be provided only by an excess of exports are in effect saying that our economy cannot become self-supporting. That is a confession of economic defeatism which a young and vigorous nation should not be willing to make.

The most immediate contribution which the United States can make to world reconstruction is to make itself prosperous.

Prosperity here means a large demand by our industries for imports. The more we import, the easier will it be for foreign countries to meet their large and urgent needs for goods. In 1939, with a gross national product of $100 billion, our imports were $3 billion. After the war, with 55 million people employed and a gross national product of $155 billion, our imports would be about $7 billion or $8 billion.

Not only should the United States make itself prosperous, but it should *keep* itself prosperous. *So important is the United States in the world economy that a depression here is bound to produce a disastrous drop in the price of raw materials throughout the world and to throw most countries into an economic tailspin.*

The United States should support the principle of a large fund to protect the exchanges of the world from temporary pressure. We should not permit differences over the details to prevent its establishment in ample time to be available during the critical period when war-stricken countries will need goods far in excess of their immediate ability to pay for them. *Some* arrangement, even though imperfect in details, will be infinitely superior to no arrangement.

Finally, the United States should take the lead in breaking down barriers to trade. We are the logical country to do this, partly because of our immense domestic market, and partly because for most of the last twenty-five years this country has been able to sell other countries more goods than they have been able to sell to us. One of the greatest contributions which the United States could make to a sound and expanding world economy would be to bring our imports, as soon as practicable, up to our exports. *In other words, the United States, in the long run, should be hard to borrow from but easy to sell to.* The United States should implement this policy (1) by continuing the negotiation of reciprocal reductions in duty, and (2) by accepting exchange rates which make foreign currencies cheaper in dollars than they were in 1939. So great will be the world's need for goods that we can be sure that any dollar exchange earned by sales to us will be converted into American-made goods and will lead to larger exports.

Time was when the United States obtained about eight per cent of its standard of living by sending goods abroad and bringing back other goods. Before the war, however, we were getting less than five per cent of our living by international trade. If, after the war, we were gradually to raise the proportion of our standard of living obtained by trading with other countries to ten per cent of domestic production, our imports would be about $15 billion or $16 billion a year. Our people would be able to buy many things which they now cannot afford, and scores of countries which export raw materials and luxury products would feel the stimulus of rapidly expanding markets. Their expanded demand for road building machinery, mining machinery, machine tools, agricultural implements, locomotives, railroad cars, electrical equipment, trucks, automobiles, and a multitude of products of our factories would create a million or more additional jobs in our factories.

Although the United States would raise its standard of living by increasing its imports and its exports, it should honestly face the fact that the resulting shifts in production and employment would temporarily be painful for some people. The increase in imports would be in commodities which other countries can produce for less than the cost at which much of our output is produced—such as sugar, wool, copper, some fats and oils, wines, winter vegetables and fruits. The increase in our exports would come from those industries in which our superiority is greatest—particularly the manufacturing industries. Finally it would be advantageous, to the country as a whole, to shift a million or two workers from agriculture, where they earn about 60 cents an hour at best, to manufacturing, where they earn better than 80 cents an hour.

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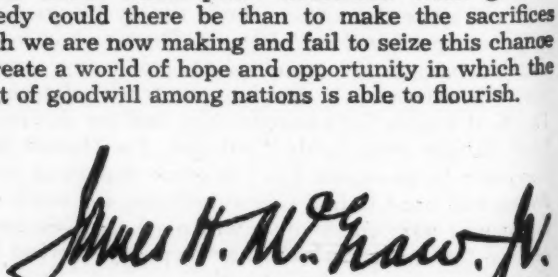
The very fact that in economic matters the rest of the world is dependent upon the United States, exposes our country to great demands and to envy and misunderstanding. The United States must be willing to help the rest of the world, but its help should take the form of assisting other countries to help themselves. Never in all history has one country had such an opportunity to give the world a rising standard of living, to foster conditions under which peace flourishes. What greater tragedy could there be than to make the sacrifices which we are now making and fail to seize this chance to create a world of hope and opportunity in which the spirit of goodwill among nations is able to flourish.



President McGraw-Hill Publishing Company, Inc.

New Books

Plastic Working in Presses

E. V. Crane. 540 *pages*, 5½x8½ *in., red clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York* 16, *N. Y. Price* $5.

Third edition of this book presents a broadened view of plasticity in three added chapters and includes new material throughout the text and in the appendix. Original object of the book was to classify metal-working operations in presses and to establish as complete a working theory as possible for predicting results for design. The author recognizes several states of plasticity, making it possible to show that press-working methods of mass production follow simple rules throughout the expanding range of engineering materials. Metals, plastics and ceramics then merge into a common problem in production of parts. Many illustrations have been gathered to show how the material and its state governs the combination of working pressure, temperature and time. Mass production, metallurgy, shearing, bending, expansion, contraction, curling, cold working, drawing operations, extrusion, hot press forging and press characteristics are discussed in the main portion of the book. Of the final new chapters, the first goes into the use of semi-permanent die materials in more flexible presses for limited lot production, the second covers the behavior of many types of materials in several states of plasticity and the third considers application of plastic flow methods to the molding of non-metallic as well as metallic powders and to the forming of sheet plastics and composite laminates.

The Liquidation Of War Production

A. D. H. Kaplan. 133 *pages*, 5⅝x8¾ *in., gray clothboard covers. Published by McGraw-Hill Book Co., 330 W. 42nd St., New York* 18, *N. Y. Price* $1.50.

Cancellation of war contracts and disposal of government-owned surpluses and plants are problems that will be of immediate concern when the war is over. To stimulate thinking and planning so that the answers to these problems may be ready when they are needed, the Committee for Economic Development sponsored a study by Dr. Kaplan, who is dean of the University of Denver School of Business Administration, on leave. This book is Dr. Kaplan's report and contains his own independent findings, with the broad principles of which the C.E.D. Research Committee is in agreement. Very briefly, the author finds that reconversion problems can be solved satisfactorily if proper precautions are taken and there is a spirit of cooperation between business, labor and government. He quotes voluminous statistics and brings in past experience wherever possible to prove his points. The book is well worth reading by those concerned with contract termination.

Conveyors and Related Equipment

William G. Hudson. 341 *pages*, 5½ x 8¼ *in., gray clothboard covers. Published by John Wiley & Sons, Inc., 440 Fourth Ave., New York* 16, *N. Y. Price* $5.

Those who seek information regarding the kind of conveyor equipment to use to best advantage will find this book helpful. It is intended for both students and engineers, but is not too elementary for the latter nor too advanced for the former. The purpose of the book is to help in weighing the recommendations of manufacturers. For this reason, and because material handling is too broad a subject to be covered completely in one volume, details of design of such related equipment as chains, bearing, shafting and gearing have been omitted.

The Oxy-Acetylene Handbook

Published by Linde Air Products Co., 30 E. 42nd St., New York 17, *N. Y.* 500 *pages*, 6x9 *in., green clothboard covers. Price* $1.50.

Planned as a basic manual on oxy-acetylene welding, cutting and related processes, this how-to-do-it book is valuable to anyone desiring to be a welder or user of the oxy-acetylene torch, and to those concerned with teaching or training students or employees. The subject matter is written interestingly, comprehensively and authoritatively and the book contains 400 illustrations. In the first of seven parts are presented the scope of applications of the oxy-acetylene flame; historical development; metal properties important to welding, particularly thermal expansion; tests for identifying metals; and various methods of preparing for welding. Considerable space is devoted to the operating principles of equipment and its care and maintenance. The second and third parts deal individually with different metals and forms available. Part IV covers miscellaneous applications. The remaining parts describe flame cutting, inspection and management, and conclude with 25 tables of welding and cutting data, properties of metals and general data.

Practical Design Of Welded Steel Structures

H. Malcom Priest. 153 *pages*, 5x8 *in., green clothboard covers. Published by American Welding Society, 33 West 39th St., New York* 18, *N. Y. Price* $1.

The author brings up to date a subject on which he first wrote 10 years ago. He finds that the fundamentals of design remain the same but points out improvements in the details of execution as a result of improvements in welding equipment, increase in experience, and new fields of application. The book is concise and well organized in its presentation. Welding processes are first distinguished and classified, then each method is briefly described. Various forms of joints, welding rods, gas cutting, qualification and inspection, codes and reports, stress distribution and temperature effects are then discussed in turn. A section on design considerations in general is followed by sections on design of girders, trusses, columns, beam connections, continuous structures and rigid frames. The book concludes with a discussion of fatigue and its effects on welded design.

Bulletins

The Asbestos Factbook

Published by "Asbestos," 17th Floor, Inquirer Bldg., Philadelphia 30, *Pa.* 16 *pages*, 5 x 7½ *in. Price* 10 *cents.*

Uses of various forms of asbestos and characteristics of the material make up half of this bulletin. Remainder of the space is devoted to the origin of asbestos, location of sources of different varieties and miscellaneous information.

Vulcanized Fibre Standards

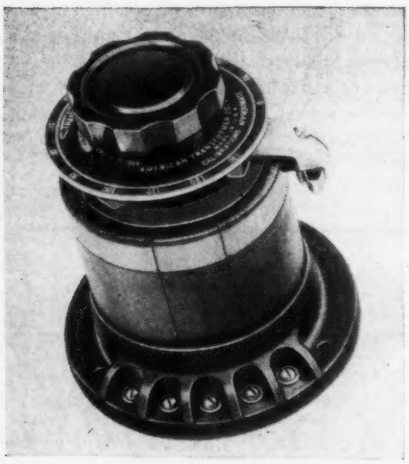
Published by National Electrical Manufacturers Association, 155 E. 44th St., New York 17, *N. Y.* 11 *pages*, 8 x 10½ *in., paper covers. Price* 25 *cents.*

All standards dealing with the manufacture and testing of vulcanized fibre that have been adopted are in this new edition. Information is included on description and standard grades; standard colors of sheets, rods and tubes; dimensions of sheets, blocks, rods and tubes; and standards for physical, electrical and chemical properties.

NEW MATERIALS AND PARTS

Voltage Regulator

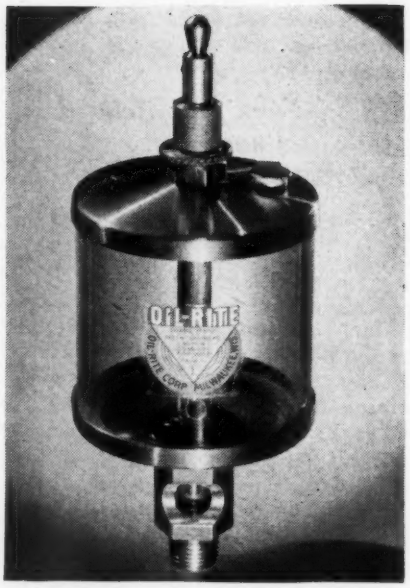
Advantages of the transformer-type regulator are offered in the latest Model TH Transtat a.c. voltage regulator. The unit has a high rating-to-size ratio. The brush arm is an accurately machined die casting that permits good heat dissipation, provides a simple means of changing brushes and protects the commutator against short-circuiting contact with the brush holder. The shaft is independent of the brush arm assembly and can be removed by drawing one pin. The base is made of phenolic plastic. Among the refinements in the new



unit are vinyl acetal insulated wire, impregnation of core and coil with a phenolic baking resin varnish, corrosion-resistant fittings and a dual-mounting arrangement for open-delta three-phase control. No load loss is approximately 5 watts and the exciting current is 0.06 amp. Voltage increments are 0.4 throughout the range of control. The units do not cause wave form distortion or alter the power factor of the load circuit. The single unit weighs 5.5 lb., the dual unit 12 lb. American Transformer Co., 180 Emmet St., Newark 5, N. J.

Gravity-Feed Oiler

For use on machine tools, engines, conveyors and other equipment a sight gravity-feed oiler regulates the rate of oil flow by means of an adjustable needle valve. A lock nut secures the desired setting. A shut-off lever on top of the oiler stops oil flow when it is in a horizontal position. An unbreakable sight in the shank permits visibility of oil flow through the drip nozzle. The reservoir wall is made of Lucite acrylic plastic. A self-closing filler cap can be opened with an oil-can spout for filling the reservoir. The bottom of the reservoir is designed so that dirt and other foreign matter will have a tendency to settle on a surface lower than the oil intake port leading to the needle valve. The lubricators are available in nine sizes with capacities ranging from 5/8 oz. to 26 oz. Oil-Rite Corp., 3482 S. 13th St., Milwaukee 7, Wis.

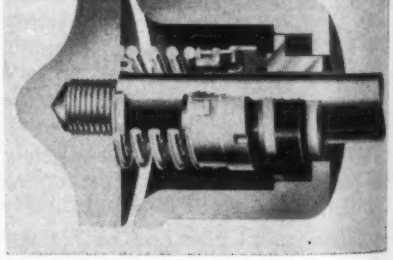


Plasticized Cotton Fabric

Resistance to abrasion and fluids features Cottonleather, a cotton fabric impregnated with a plasticizer. Originally developed as a substitute for shoe leather, the material is now proposed for such applications as stair tread and floor covering, chute lining, oil seals, slasher frictions, clutch facings, washers, valve seatings, gaskets, picker friction and mounts. The material is available in thicknesses ranging from 1/24 in. to 9/48 in. and in sheets up to 24x96 in. The fabric can be laminated with either flexible or rigid cements to almost any desired thickness. Tan is the normal color, but red and green are also available. Properties include flexibility not as great as rubber; tendency to harden with age, which increases abrasion resistance at the expense of flexibility; heat resistance of 250 deg. F. for 4 hr.; oil resistance; tensile strength about the same as cotton fabric; coefficient of friction of 3 to 3.5 deg., much of which is retained when wet; deteriorates under strong acids and alkalis; compatible with waxes, paints and varnishes. Southern Friction Materials Co., Charlotte, N. C.

Bellows-Type Shaft Seal

Furnished as a complete sealing unit, the John Crane shaft seal consists basically of a flexible synthetic rubber bellows, the tail end of which grips and seals along the shaft; a stationary floating seat, held in a synthetic rubber sealing ring; and a positively driven sealing washer that turns with the shaft and is held against the stationary seat by spring pressure. The contacting faces of the washer and seat are lapped to form a leak-proof seal. The flexing head of the bellows offers no resistance to the spring. This design allows the sealing washer to remain in contact with the seat as the sealing faces wear, and provides automatic compensation for shaft vibration and end-play. A protecting

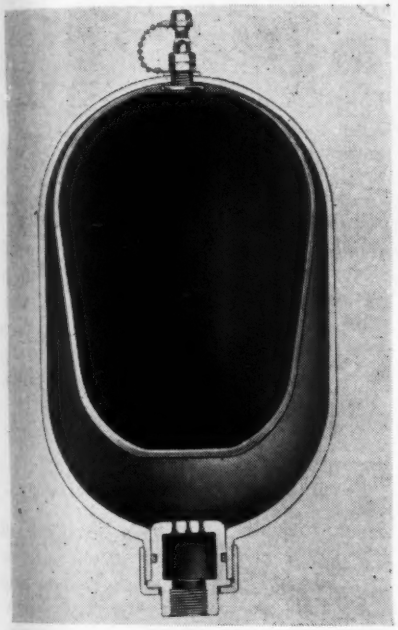


ferrule, fitting the shaft loosely, guides the flexing bellows head and prevents the synthetic rubber from contacting the shaft. The stationary floating seat used in most installations is held in a synthetic rubber holding ring. This construction permits easy insertion, prevents stress distortion of the sealing face during the installation and allows the face to be lapped before insertion. The

flexible bellows and holding ring are molded of special synthetic rubber stocks for maximum resistance to oil, hydrocarbons, refrigerants, water and anti-freeze solutions. Crane Packing Co., 1839 Cuyler Ave., Chicago 13, Ill.

Hydraulic Accumulator

New applications of hydraulics in many fields are possible with the release of a hydraulic accumulator formerly available exclusively for aircraft. It consists of a one-piece seamless steel shell that contains a one-piece synthetic rubber bladder having an integrally molded air valve. The accumulators are available for operating pressures up to 3,000



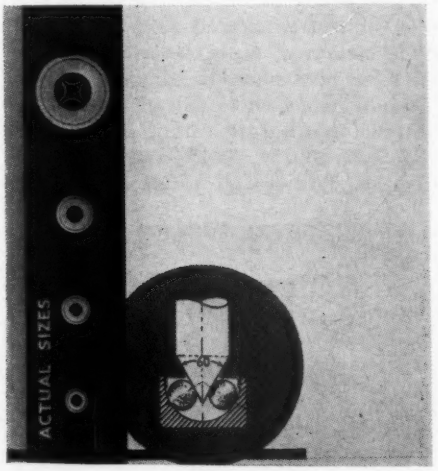
lb. per sq. in. capacities of 1/3, 1, 2½, 5, 10 and 25 gal. For larger capacities several units can be installed. Overall length ranges from 8 1/16 to 52 5/8 in. and overall diameter ranges from 4 1/8 to 12¾ in. Greer Products Corp., 39 W. 60th St., New York 23, N. Y.

Time-Delay Relay

Known as Type TD-4 a time-delay relay has a special overtravel mechanism that delays complete recycling in case of momentary power interruptions. The unit automatically resets and is designed for surface mounting. It has a moisture-resistant surface-type mounting case and is used for controlling the closing of plate circuits in such equipment as radio transmitters or rectifiers. Silver butt-to-butt contacts are rated 10 amp. at 110 volts, 5 amp. at 220 volts or 3 amp. at 440 volts. The time scale is adjustable from 0.75 to 105 sec. R. W. Cramer Co., Centerbrook, Conn.

Pivot-Type Ball Bearings

Now available in sizes ranging from 2-10 mm. O.D., pivot-type miniature ball-bearings are made of beryllium, stainless or chrome steel. The bearing races are machined from solid bar stock and highly finished on raceway and exterior surfaces. Each bearing is equipped with four balls of the same material as the cup and fitted with a retaining cap. Miniature Precision Bearings, Keene, N. H.



Treated Wood

By impregnating wood with a water-soluble solution of uncondensed methylolurea by the full-cell, or partial-vacuum procedure, the wood can be given improved hardness, strength, dimensional stability and resistance to flame, rot, chemicals and moisture. When the solution is forced into the wood it first enters the cell cavities, then it rapidly diffuses into the cell walls where the wood acids cause it to polymerize and become an insoluble urea resin. Several controllable variables enter into the process and are capable of giving a wide range of results. The wood article should be cut or fabricated almost to its final form for most economical use of the process. The wood expands about 6 percent during treatment so that allowances must be made accordingly. Slower rates of sawing, cutting and turning; different tool settings; harder tools or more frequent tool sharpening may be required in working treated wood. Screw-holding strength and nail-holding ability of wood appear to be improved. Highly compressed treated wood can be machined or worked in a manner similar to plastics. Wood can be formed during the treating cycle if it is subjected to heat and pressure while the resin is still in the fusible stage. Thus, treated wood can have a homogeneous surface that requires no filling, sanding or polishing. It is also possible to apply moderate pressure sufficient to compress and consolidate only the surface or outer zone of the treated wood to produce a finished, hard surface. Treating wood with methylolurea does not change the color of most woods, although some are lightened. However, by adding dyes to the solution the wood can be given any desired color. The process also offers the possibility of what might be called case-hardened wood. Present indications are that 3 in. is the practical limit for depth of penetration of the solution. Penetration up to this depth can be controlled from the standpoint of both depth and concentration by adjusting the variables. E. I. du Pont de Nemours & Co., Wilmington 98, Del.

Hermetically Sealed Leads

Constructed of Pyrex glass with Kovar electrodes and metal collars, hermetically sealed leads are suitable for use in transformers, condensers, coils, filters and similar components. The Pyrex glass assures high dielectric strength, immunity to reasonable thermal or mechanical shock and freedom from moisture absorption. The surface of the glass insulator is such as to provide maximum water shedding properties. The Kovar electrode and collar can be soldered, brazed or welded to the unit enclosure. Standard shapes and sizes are available in a wide variety of shapes. The Pyrex glass and Kovar

metal form a tight chemical bond so that internal gas pressure can be maintained. Electrical Industries, Inc., 42 Summer Ave., Newark 4, N. J.

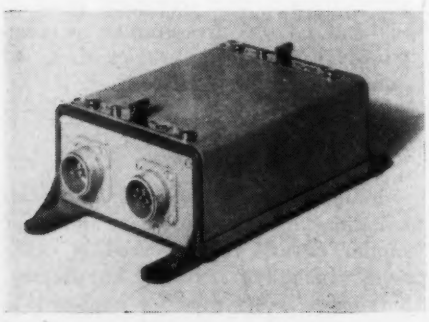
Relays

Two new relays designed for circuit switching in radio equipment and other similar devices can be used in other fields, including aircraft installatons. KR Series is designed for applications

where size and weight are important factors. Where current is not too limited, the d.c. types can be adjusted to withstand the vibration encountered in most aircraft applications. Units can be provided with mechanism for easy adjustment of armature spring where a critical pull-in value of current or voltage is required. Coils for voltages up to 110 volts, 60 cycles or 60 volts d.c. and contact arrangements up to and including double-pole, double-throw are available. Dimensions of KRD-4 are 1 1/16 x 1 5/16 x 1¼ in., not including mounting stud. Weight is from 1¾ to 2 oz. Mounting is by two holes on 7/16-in. centers. One hole is 5/16-in. in diameter to accommodate a projecting lug and the other is approximately 0.140 in. in diameter for a 6/32-in. mounting stud. KL Series has approximately twice as much coil space and a larger number of poles than the KR Series. These relays operate on values as low as 0.2 watts, combining sensitivity and the wiping action of a spring-mounted contact. In addition, the large coil provides more power on the multiple poles for applications which must withstand aircraft vibration. Coils for voltages up to 220 volts, 60 cycles or 100 volts d.c. and contact arrangements up to and including four-pole, double-throw are available. KLB-1 measures 1 1/16 x 1 1/16 x 1 1/16 in. Weight is from 3½ to 4 oz. Mounting is by two 6/32-in. tapped holes on 1 7/16-in. centers. Contacts of both series are of fine silver and are rated at 3 amp. 100 volts, 60 cycles, non-inductive. Potter & Brumfield Mfg. Co., 106 N. First St., Princeton, Ind.

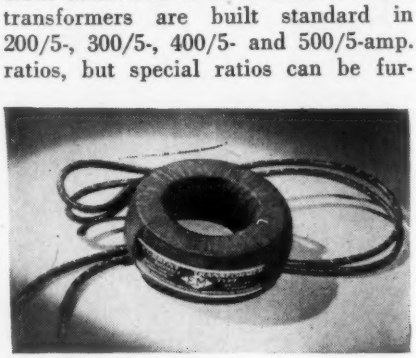
Dust-Tight Inclosure

Combinations of aircraft control devices can be housed in a standard dust-tight inclosure that accommodates various G-E aircraft control relays and contactors with ratings up to and including those of a 100-amp. aircraft contactor. Because the inclosure is made of aluminum, with cast aluminum end frames, it is light in weight, yet provides mechanical protection. Gasketing protects against foreign matter. A convenient self-locking latch permits removal of the cover without disconnecting wires and without using tools. This latch also has a provision for wire locking. In addition, the end plates are adaptable for various sizes of AN connectors or terminal posts. The inclosure is available in various over-all lengths up to 19 in. General Electric Co., Schenectady, N. Y.



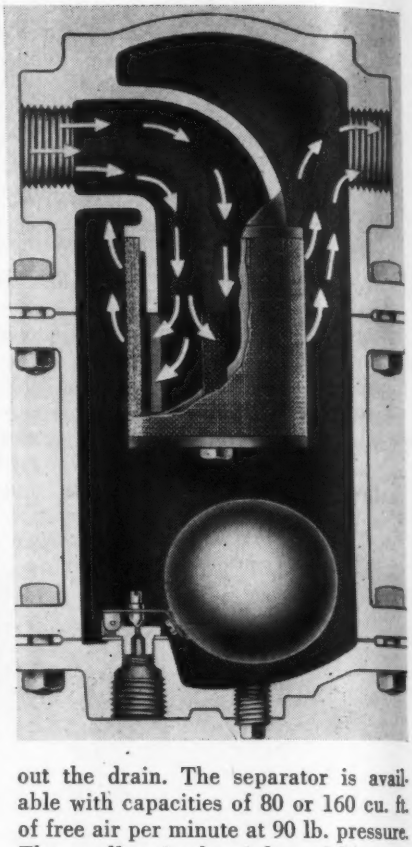
Current Transformers

For use with any indicating-type a.c. ammeter, DoNut current transformers are an amplification of the present line. The unit, of the "inserted-primary" type, is slipped over the bus or conductor to be measured, taped or lashed in place if for permanent installation, and the leads connected to the ammeter. These transformers are built standard in 200/5-, 300/5-, 400/5- and 500/5-amp. ratios, but special ratios can be furnished. Ratio accuracy is 1 percent for ranges above 300 amp. and 2 percent for ranges 300 amp. and below on frequencies of 25 to 133 cycles, and from 15 to 150 percent load. Rated burden is 2 volt-amperes. Lower ratios can be obtained by passing the primary conductor through the transformer two or more times. Special-ratio transformers can also be supplied. Liberal-sized core of the transformer is built up of low-loss steel laminations, tightly taped. The toroidal coil has low resistance. Electric Machinery Mfg. Co., Minneapolis 13, Minn.



Self-Draining Separator

Known as Type SA, a self-draining compressed-air separator has a built-in trap mechanism that automatically releases water, oil and other moisture that has been removed from the air. The separator employs principles of expansion and change of direction. Entering air is first allowed to expand slightly, there precipitating most of the entrained moisture. Then it passes through a labyrinth of coarse wire mesh, changing direction of flow abruptly many times and surrendering the remaining particles of foreign matter. The trap mechanism has a spherical float and chrome-steel valve and valve seat. It is mounted on the bottom plate of the separator body. Moisture drops to the bottom and when the level is sufficient to raise the float the valve opens and the liquid flows out the drain. The separator is available with capacities of 80 or 160 cu. ft. of free air per minute at 90 lb. pressure. The smaller size has inlets of ¾, 1, or 1¼ in. and the larger has inlets of 1½ or 2 in. Johnson Corp., Three Rivers, Mich.



Extruded Plastic Tubing

Improved resistance to heat, oil and gasoline-benzol are features of extruded vinyl tubing that is said to have the same electrical properties as conventional tubing. Wires insulated with Natvar 400, as the tubing is called, can be soldered without special care or technique and without flow or opening of the tubing near the point of soldering. The tubing has a tensile strength in excess of 3,000 lb. per sq. in. with an elongation from 170 percent to 410 percent, depending on formulation. It remains flexible down to —80 deg. F. and is suitable for oil lines, sheathing and other protective coverings in applications where adverse oil, solvent or acid conditions are severe and where protection from chemicals or vibration is required over a wide temperature range. National Varnished Products Corp., Woodbridge, N. J.

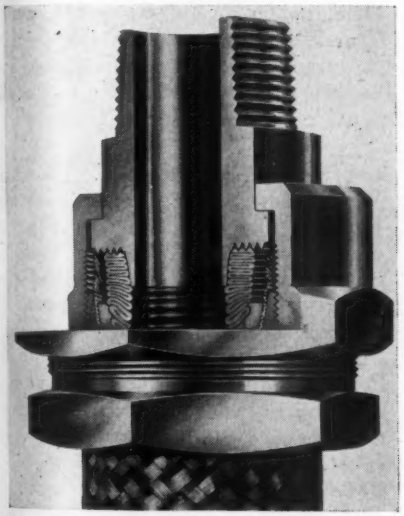
Shaded Tracing Vellum

Automatic shading, characteristic of Doubletone drawing board, has been incorporated in tracing vellum. This allows the application of cross-hatch shading by dipping a brush in a spe-

cial fluid and applying it to the paper. Diagonal-line shading is achieved by applying a second chemical. Solids are put into the drawing in the usual way with india ink or pencil and the final result is white, black and two tones of gray. These drawings can be reproduced photographically or in blueprint, Ozalid or black-and-white equipment. Craftint Mfg. Co., 210 St. Clair Ave. W., Cleveland 13, Ohio.

Detachable Coupling

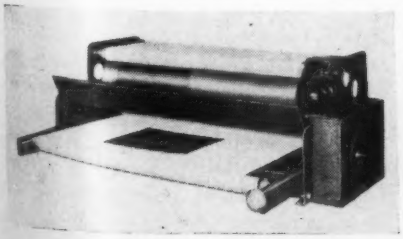
Mechanical self-sealing is an advantage of a detachable brass coupling for helical metal hose ranging in size from ¾ to 1½ in. I.D. No brazing is employed in the unit which consists of the nut, back, stem and split ring. When assembled, the convolutions of hose and the metal braid are held by pressure, as shown in the accompanying illustration. The coupling withstands pressure tests up to 800 lb. Another feature is a self-contained union that permits the pipe-



thread end of the coupling to be screwed directly into the machine fitting and the union tightened without twisting the hose. The coupling can be assembled with ordinary shop tools. Packless Metal Products Corp., New Rochelle, N. Y.

Table-Type Print Dryer

For drying blueprints or black-and-white prints a compact electrically heated dryer is equipped with variable-



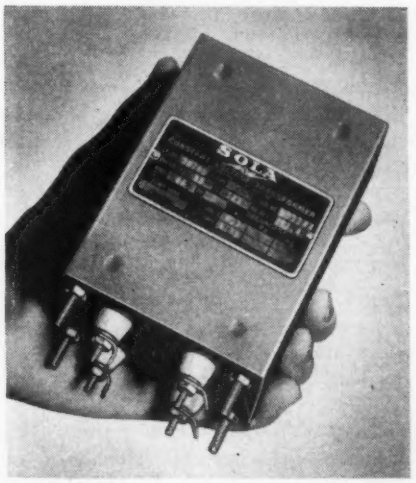
speed drive motors and controllers in addition to standard heat regulation. This permits instantaneous speed changes over a range of 6 in. to 3½ ft. per min. Two sizes are available, one for handling prints 26 in. wide and the other for prints 44 in. wide. Current consumption of the 26-in. dryer is 14 amp. on 110 volts or 7 amp. on 220 volts; and of the 44-in. dryer, 23 amp. on 110 volts or 12 amp. on 220 volts. The dryer has a pressed-steel framework, specially woven seamless band and a heavy seamless copper revolving drum. Steel-clad, refractory-insulated, Nichrome heaters with nickel contacts and asbestos-insulated nickel wire are used. The 26-in. dryer is 40 x 28 x 13 in. The 44-in. dryer is 58 x 28 x 13 in. Peck & Harvey, 4327 Addison St., Chicago 41, Ill.

One-Coat Porcelain Enamel

Characteristics of high-quality white cover coat and adhesion of a good ground coat have been combined in Mirac, a single-coat porcelain enamel for direct application to steel. It has high opacity, brilliant luster and good resistance to physical and thermal shock. The coating, which is fired at 1,500 deg. F., requires no special handling. Pemco Corp., 5601 Eastern Ave., Baltimore 24, Md.

Transformer

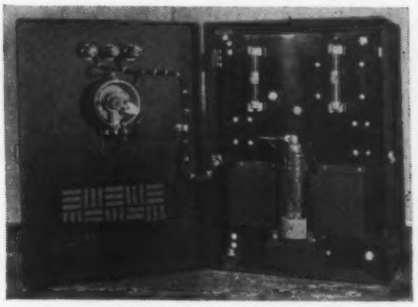
Built-in automatic voltage regulation of filament supplies features a constant-voltage transformer enclosed in a hermetically sealed case and designed for chassis mounting. Rated at 6.3 volts, 17 volt-amperes output, it will maintain that value within ±1 percent, regard-



less of line voltage variations as great as ±12 to 15 percent. The unit is suited to the stabilization of oscillator circuits. Electronic equipment in which this transformer is a built-in component of the basic design does not require filament volt meters or manual controls. Sola Electric Co., 2525 Clybourn Ave., Chicago 14, Ill.

Spot-Welding Control

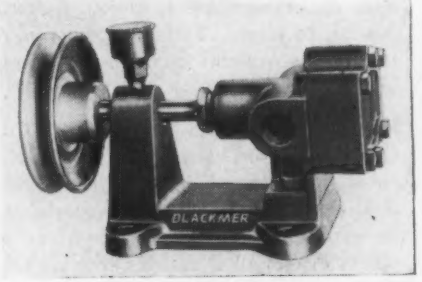
Suitable for welding small objects of high conductivity, such as aluminum or copper, a welding timer with heat control for timing intervals of one-half cycle or less has been announced. Welding current is made to start at the same point on the voltage wave for every operation in the SP-18, ½-cycle unit. The timer is furnished as a separate control



for use with existing small bench welders and also in combination with a small welding transformer. One thyratron rectifies alternating current to charge a firing capacitor and fires the small ignitron power tube. Heat control is accomplished by a phase-shift method. The timer is rated at 230/460 volts, 50/60 cycles. Dept. 7-N-20, Westinghouse Electric & Mfg. Co., E. Pittsburgh, Pa.

Small-Capacity Rotary Pump

Capacities ranging from ⅔ to 10 gal. per min. are available in a line of special rotary pumps. The pumps are of compact design, operate quietly and are light in weight. A built-in relief valve is optional. They are furnished with base and flexible coupling for direct connection to prime mover, for V-belt or flat-belt drive and with special brackets to meet mounting specifications. The pumps are available in all-iron, bronze-fitted or all-bronze construction. The special "bucket design" makes the pumps self-adjusting. The buckets can be easily replaced. Blackmer Pump Co., Grand Rapids 9, Mich.



Manufacturers' Publications

Speed Reducers — Cleveland Worm & Gear Co., 3301 E. 80th St., Cleveland 4, Ohio. Catalog No. 300, 16 pages. Gives details of Speedaire fan-cooled worm-gear reduction units with text, cutaway photographs, charts, diagrams and tables.

Laminated Precious Metals—D. E. Makepeace Co., Attleboro, Mass. Folder 4 pages. Properties and advantages of laminated precious metals are described and typical shapes and cross-sections of sheet, tubing, wire and fabricated parts available are illustrated.

Blower Wheels — Janette Mfg. Co., 556 W. Monroe St., Chicago 6, Ill. Bulletin 24-1, 20 pages. Performance data and dimensions of various types of blower wheels are featured.

Baking Enamel — Standard Varnish Works, 2600 Richmond Terrace, Staten Island, N. Y. Bulletin, 2 pages. Lists properties, baking schedule and application information for Rockloid polyester resin baking enamel.

Plastic—Columbia Chemical Div., Pittsburgh Plate Glass Co., Barberton, Ohio. Data Sheet No. 44-1, 4 pages. Lists general properties and characteristics of Allymer C. R. 39, new trade name selected for the company's line of allyl resin monomers.

Thermal Switches—Fenwal, Inc., Ashland, Mass. Catalog, 44 pages. Details of Thermoswitches, 20 different types and selection and application are covered in text, sketches and tables.

Industrial Papers—Central Paper Co., Muskegon, Mich. Brochure, 16 pages. Industrial uses of papers of various types are described, featured by a chart that shows characteristics and uses of 68 types.

Lubrication—Farval Corp., 3295 E. 80th St., Cleveland 4, Ohio. Bulletin No. 25, 16 pages. Tells how centralized lubrication systems increase the output of machinery.

Fasteners—Lamson & Sessions Co., Cleveland, Ohio. Book, 180 pages. Revision of "Bolts, Nuts & Screws," first published in 1941, this edition is about three times larger and is made up of reprints of technical articles that contain useful and relevant information for the user and buyer of bolts and nuts in production quantities.

Rectifiers—Rectifier Div., Fansteel Metallurgical Corp., North Chicago, Ill. Bulletin RDP-105, 8 pages. Offers technical information, specifications, illustrations, wiring diagrams and other data on more than 130 standard selenium rectifiers.

Heat Exchangers—National Carbon Co., 30 E. 42nd St., New York 17, N. Y. Catalog Section M-8802, 24 pages. Thermal conductivity and physical and chemical properties of carbon, graphite and Karbate materials are presented and many types of heating and cooling units made of these materials are illustrated.

Springs—Accurate Spring Mfg. Co., 3811 W. Lake St., Chicago 24, Ill. Handbook, 36 pages. Contains fundamental data and information, much of it in tabular form, on round wire extension and compression springs for the special interest of design engineers.

Socket Screw Products—Western Automatic Machine Screw Co., Elyria, Ohio. Catalog, 32 pages. Data on capscrews, setscrews, stripper bolts, pipe plugs, hexagon keys and special socket screws are included along with information on comparative sizes and strengths of screws and other useful data.

Fasteners—Parker-Kalon Corp., 200 Varick St., New York, N. Y. Users' Guide, 18 pages. Application information for self-tapping screws is presented in tabular form, with sketches to illustrate special heads and forms.

Meehanite—Meehanite Research Institute of America, Pershing Square Bldg., New Rochelle, N. Y. Bulletin No. 19, 4 pages. Castings and welded fabrications for the same parts of diesel engines and heavy-duty presses are compared, including cost and weight data.

Infra-Red Gas Burners—Burdett Mfg. Co., 19 N. Loomis St., Chicago 7, Ill. Catalog, 114 pages. Burners, mixing equipment, valves, gas pressure regulators, motors and blowers, pilot safety devices, temperature controls and electrical accessories are described and engineering data on velocity pressures, motor ratings, measurement of electrical power, calculating power requirement tables and charts, heat losses and thermal capacity of gases are given.

Steels—Monarch Steel Co., 543 W. McCarty St., Indianapolis 7, Ind. Bulletin, 24 pages. Gives properties and presents many typical application studies of Speed Treat and Speed Case specially processed cold-finished steel bars.

V-Belts—Industrial Products Div., B. F. Goodrich Co., Akron, Ohio. Handbook, 44 pages. Highlight is a chapter on the proper selection of fractional-horsepower belt drives, with 27 pages devoted to tabular information.

Gear Pumps—Hydro-Power Systems Div., Hydraulic Press Mfg. Co., Mt. Gilead, Ohio. Bulletin No. 440, 16 pages. Gives design and operating details of Models G and LG gear pumps for medium-pressure hydraulic applications.

Lock Washers — Reliance Spring Washer Div., Eaton Mfg. Co., Massillon, Ohio. Folder No. 142, 6 pages. Contains general information and reference data on type of steel, section sizes and weights of all types of spring lock washers, for engineers and designers.

Lubrication—Alemite Div., Stewart-Warner Corp., 1826 Diversey Parkway, Chicago, Ill. Four bulletins, 8 pages each. LubroMeter, simplest form of centralized lubrication; Dual Progressive, single-line progressive system of centralized oil or grease lubrication; Progressive system, original Alemite lubricating system; and Dual Manifold, dual-line system of centralized lubrication designed for high-pressure grease or oil lubrication are described.

Aluminum — Reynolds Metals Co., 2500 S. Third St., Louisville, Ky. Bulletins 17S, 8 pages, and 31A, 12 pages. Former covers specifications and properties and characteristics of extruded tubing and pipe, and latter gives similar engineering information for rolled or extruded wire, rod and bar.

Plasticized Cotton Fabric—Southern Friction Materials Co., Charlotte, N. C. Catalog, 4 pages. Details physical properties, specifications and suggested applications of Cottonleather, an abrasion-resistant fabric.

Safety Valves—J. E. Lonergan Co., Second and Race Sts., Philadelphia 6, Pa. Bulletin 501-A, 8 pages. Interprets safety valve standards developed under WPB and National Bureau of Standards auspices and describes and illustrates Lonergan designs corresponding to these standards.

Influence of Temperature On Molded Phenolic Materials

T. S. CARSWELL, D. TELFAIR *and* R. U. HASLANGER
Plastics Research Division, Monsanto Chemical Company

DATA given in the accompanying charts for tensile, flexural and impact strengths of molded plastic materials, have been obtained from test specimens. The data should serve as a basis for selecting the most suitable material to use for a particular application. Since the form factor, mold design, molding conditions, treatment following molding, and numerous other factors affect the strength of the molded article, the final evaluation of the material should be based on actual service tests on the finished product.

The results plotted in the curves are for similar materials tested under identical conditions. All specimens were compression molded. Data are for short-time temperature effects.

Filled materials tested contained 50 percent phenol-aldehyde resin and 50 percent filler with the exception of the asbestos-filled material which contained 40 percent resin and 60 percent filler.

Tension specimens for all the filled materials were machined from $5\times7\times\frac{3}{16}$ in. slabs, following the requirements for type 1 test specimen in the A.S.T.M. Tentative Methods of Tension Testing of Plastics (D638-41T), except for the 7-in. over-all length. The pure resin specimen was molded in a compression mold of the type specified for producing type 1 samples according to Methods D638.

Impact and flexural test specimens, $\frac{1}{2}\times\frac{1}{2}\times5$ in. bars, of the pure resin, asbestos and wood-flour filled materials were molded in a 5-bar gang mold.

The cord, sisal fiber, and macerated fabric filled impact grade materials were molded in a single bar mold.

Tension tests were run according to A.S.T.M. Methods D638 using the type 1 specimen with a thickness of 0.1875± 0.008 inches. Flexure tests were run according to A.S.T.M. Standard Methods of Testing Molded Materials Used for Electrical Insulation (D48-39).

For impact and flexural test specimens, the dimensions

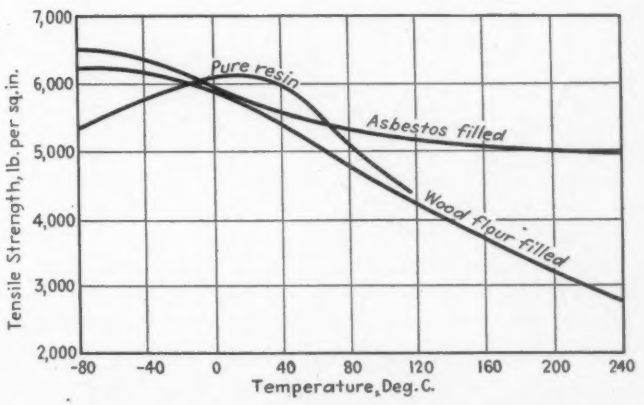


Fig. 1—Change of the ultimate tensile strength with temperature for low impact phenolic molding compositions.

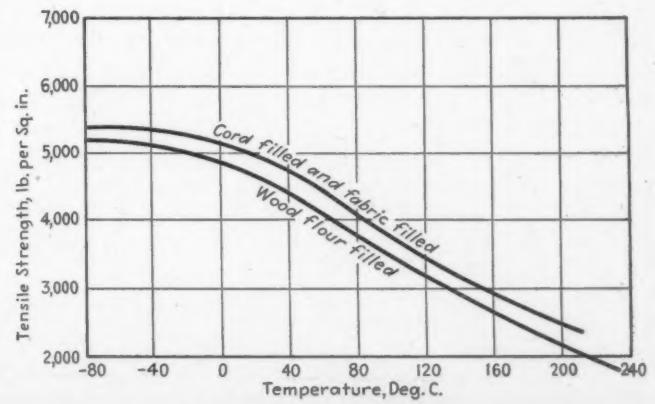


Fig. 2—Change of the ultimate tensile strength with temperature for impact grade phenolic molding compositions.

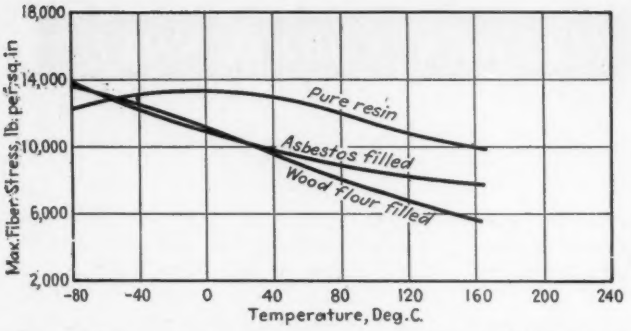


Fig. 3—Change of the maximum fiber stress, in flexure, with temperature for low impact phenolic molding compositions.

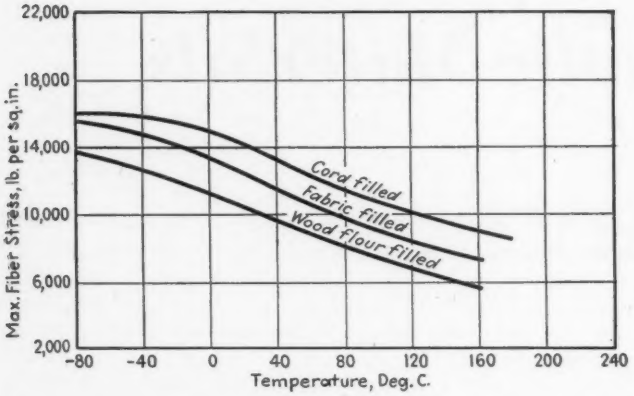


Fig. 4—Change of the maximum fiber stress, in flexure, with temperature for impact grade phenolic molding compositions.

were held to 0.512±0.006 in. on the variable dimensions for all specimens.

All specimens were conditioned after molding for 48 hr. at 50±3 deg. C. (122±5.4 deg. F.), and placed in a dessicator after removal from the oven.

Prior to testing, the specimens were conditioned at the desired temperature for from 4 to 5 hr. Tests were run immediately upon removal of test specimen from the chamber.

The screw-type testing machine, with constant rate of crosshead motion, used for tensile and flexural tests, was equipped with an insulated housing which inclosed the tension grips or flexural supports and the specimen. Temperatures from 60 deg. C. to 225 deg. C. (140 deg. F. to 437 deg. F.) were obtained by circulating dry air over heaters inclosed in the cabinet. For temperatures from 25 deg. C. to −80 deg. C. (77 deg. F. to −112 deg. F.) dry air, precooled with solid carbon dioxide, was circulated in the cabinet.

Impact data were obtained using the notched Izod method in which the stress was applied perpendicular to the direction of the molding pressure.

The material for this Reference Book Sheet is briefed from a paper by the authors, "The Influence of Temperature on the Mechanical Properties of Molded Phenolic Materials," which has been published in American Society for Testing Materials *Proceedings*, Volume 42, 1942.

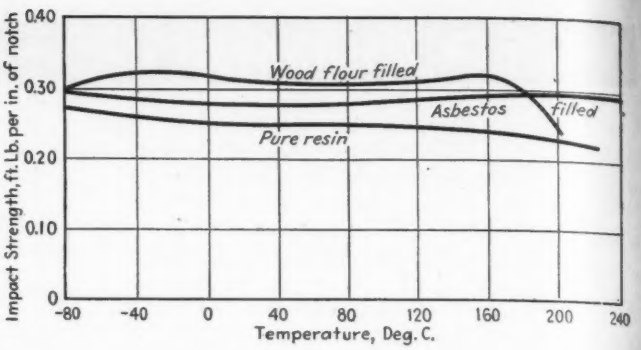


Fig. 5—Change of the notched Izod impact strength with temperature for low impact phenolic molding compositions.

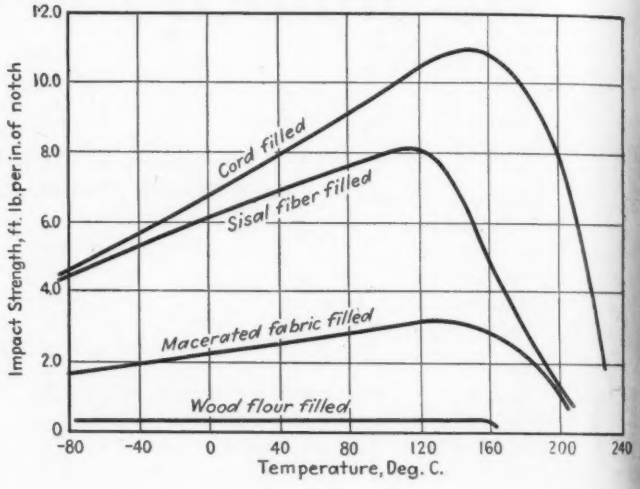


Fig. 6—Change of the notched Izod impact strength with temperature for impact grade phenolic molding compositions.

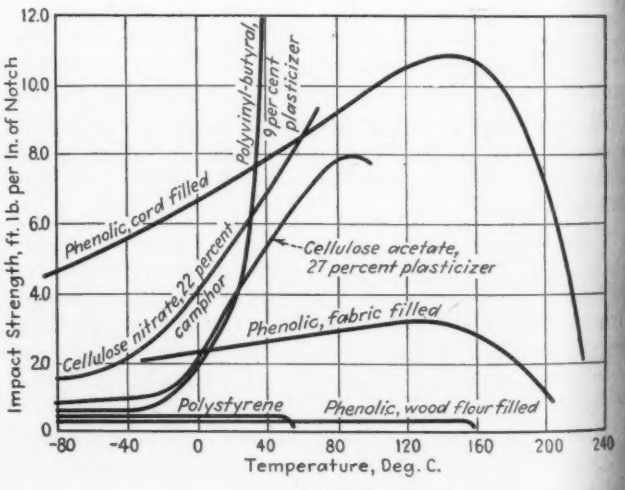


Fig. 7—Change of impact strength with temperature for various plastic materials.